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THE INTRODUCTION OF BLOOD-GROUP B INTO EUROPE

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THE progressive eastwardly rise in the proportions of group B in Europe is a matter of common knowledge, and the subject of frequent comment. Over ten years ago, Bernstein ('30) concluded that the source of Europe's group B is to be sought in Asia, and his opinion is shared by most writers, regardless of their views with respect to other blood-group questions. Boyd ('40) holds the special view that the former absence of group B in Europe was due to the fact that the early European populations had lost the B factor at some time in the past, through the operation of chance variations in small isolated ethnic groups.[1]

However, since there is no considerable disagreement with regard to the main premise, only one question remains to be answered, namely, *when* and *by whom* was the B factor introduced into Europe? It is now becoming evident that definitive answers to queries such as this

[1] Experimental evidence from the study of insects is said to support this premise. However, although purposeful, controlled experimentation may demonstrate that a given mechanism is theoretically possible, this is not to say that it must, or even could have been operative under uncontrolled conditions, involving the human or subhuman animal. If one should choose to accept a set of assumptions different from those chosen by Boyd, one would be equally justified in concluding that some branches of mankind have never possessed the blood group factor which they now lack.

one can never be forthcoming from the serological data alone, but must derive from a detailed consideration of the other disciplines as well.

The blood group factors are not esoteric abstractions, to be interpreted intuitively; they are concrete biochemical entities, present in the tissues and the blood of every human being, and they constitute a part of his genetic heritage. A complete understanding of these factors can be possible only from a consideration of all the various kinds of data which may be available regarding the populations whose blood groups are under consideration. And it is only when such a complete understanding is more closely approached that the blood groups may be expected, in their turn, to be of assistance to the other disciplines.

Since the problem under present consideration involves only one of the three inheritable blood group factors, and since the historical adnexa are reasonably complete, it offers a fair test of the method which it is proposed to adopt. This method consists of the combined use of the historical facts, the ethnic data, and the present distributions of the B factor in the relevant populations. As concerns the present argument, the outstanding historical fact is undoubtedly the occurrence of periodic mongoloid and mongol-white expansions from Asia into Europe, commencing in the 5th, and ending in the 15th centuries of the Christian era.[2]

Until recently, few anthropological or serological data were available regarding the peoples whose ancestors were involved in, or historically associated with, the events of that era. Within the last two decades, however, the efforts of the Russian anthropologists have shed much light upon the physical characters and the blood groups of the native tribes of European and Asiatic Russia (Vishnevsky, '36). In addition, much new data exists regarding the peoples of Hungary, Poland, and the other peoples of the contact zone.

During the past two years, the results of these researches have become available in English, and in compact form. The physical characters are summarized in Prof. Coon's book, *The Races of Europe* (Coon, '39), while the blood groups are tabulated in a comprehensive

[2] The conquest of the Alans and the Ostrogoths in the 4th century by the Huns under Balamir is not relevant, for reasons which will appear.

monograph by Prof. Boyd ('39).[3] As a result, it is now possible to attempt a detailed correlation between the physical and the serological characteristics of the descendants of the various elements involved in the Asiatic invasions of the Middle Ages.

The researches of Bartucz have removed all doubt that the Huns and the Avars of the invasions of the 5th and 6th centuries were true mongoloids. In fact, the studies made by Bartucz upon thousands of Avar cemeteries indicate two clearly differentiated monogloid types of crania, those of the Huns being dolichocranic, and those of the Avars brachycranic. The modern representatives of these two kinds of mongoloids are said to be the modern Tungus and the modern Buriat Mongols, respectively (Coon, *loc. cit.*, p. 231). Both types of crania were found in most of the graves, but the Avar type was more frequent, and in some graves only one of the two kinds was found. From the size and the numbers of the Avar cemeteries, Bartucz concludes that the Asiatic invaders played an important part in the peopling of Hungary and of the entire Danube basin (Coon, *loc. cit.*, p. 229 ff.).

During some ten centuries, the Don country of southern Russia seems to have served as a central depot for these peoples, and especially for the various Turkish-speaking tribes allied and related to them, who made up the greater bulk of the invading armies. Indeed, it was the latter who conducted the numerous campaigns into the Danube areas, into Asia Minor and North Africa, and even into Italy. The Magyar invasion of Hungary in the 9th century was carried out entirely by such 'Turks'.

In the 13th century, vast hordes of true mongoloids under the leadership of Genghis Khan again overran eastern Europe. They conquered Poland and Hungary, and reached the borders of Saxony. These armies are said to have incorporated most of the central Asiatic Turks, but in any case, their cranial type was the same as that of the purely mongoloid Kalmucks, who are a remnant of that invasion, and of the earlier Avars and their modern representatives, the Buriat Mongols (Coon, *loc. cit.*, p 235).

It is the considered opinion of this writer that group B was brought into Europe by the brachycephalic mongoloids and their followers during the ten centuries of intermittent invasion, conquest and occupation,

[3] As a matter of convenience for the writer and the reader alike, almost all of the anthropological data and the blood group data have been taken from the works of Coon and Boyd, respectively.

and that before their arrival the B factor was almost absent from European populations. Objective proof of the validity of this conclusion could be afforded only by the performance of blood group tests upon documented skeletal material from the appropriate areas and the relevant time levels. Such studies can and should be performed in connection with all such problems,[4] but even in their absence, a strong case can be made out in this instance from the blood group distributions of the living populations, studied in conjunction with other data relating to them.

In order to be acceptable, the evidence must involve five distinct categories of populations, and must fulfill the following requirements with regard to them:

(1) The modern descendants and representatives of the pure mongoloid invaders must be shown to have very high proportions of group B. These proportions must be higher than those present in any of the four other categories.

(2) The mixed (partly mongolized) populations whose ancestors accompanied, and for long periods superseded the Mongols along the path of invasion must be possessed of lesser, but still quite high proportions of group B.

(3) The European populations in the zone of contact, known to have borne the brunt of the invasions, and in consequence to have mixed with the invaders to some extent, must have considerably smaller amounts of group B than the Turks and Tatars who largely make up the 2nd category, but more than the peoples of the next class.

(4) Those people who were geographically remote from the scene of the invasions must have smaller amounts than any of the first three categories, having acquired the B factor chiefly through diffusion.

(5) The descendants of those populations which fled from the invaders, and have lived in comparative isolation until the present time, should be found to have the smallest proportions of group B of all, even less than those populations who were distant from the contact zone.

Fortunately, sufficient data now exists to make possible the almost complete fulfillment of all these requirements. In addition to listing all the available blood-group data from Europe and Asia, Boyd's

[4] The reliability of blood group tests upon human bones was recently demonstrated by the use of material obtained through the courtesy of the Doctors Boyd (Candela, '40).

invaluable tables perform the added service of distinguishing between the European Russians of Russia and Siberia, and the non-European peoples of the entire U.S.S.R. (Boyd, '39). In addition to the peoples of the Caucasus, who represent the refugees of the 5th Category, the non-European populations include for the most part the mongoloid and the mixed Altaic and Finno-Ugrian tribes, extending from the gates of Europe to the Buriat-Mongol Republic and the Far East Territory.

METHOD OF COMPARISON

Before this material can be utilized, it is necessary to decide upon a method of analysis upon which the comparisons shall be based. Since it is proposed to compare actual ethnic groups, occupying the same or overlapping territories, it is obvious that graphic methods such as the commonly used "contour lines of equal frequency" will be of no assistance. What is desired is an expression of the frequency of group B in each of the individual ethnic groups, and not in a general geographical ambient. For this reason, the five categories of peoples will be compared directly in terms of their actual frequencies of q, which represents the percentage frequency of the gene for group B.

The next question has to do with the choice of samples to be included or discarded. This matter is of some importance, and will require discussion, since it has contributed to the current confusion. Briefly, it may be said to stem from the genetic equation, which requires that the sum of the frequencies of the three blood-group genes, p, q, and r, shall be 1.000, or unity. When the sum of the gene frequencies deviates from unity, the importance of that deviation depends mathematically on the size of the sample, so that a larger deviation is "permitted" in a sample of 100 persons than in one of one thousand.

The various authors differ as to the relative size of the deviation which they will permit in an 'acceptable' series; thus, Boyd demands that the deviation shall be not more than twice the probable error, while Haldane ('41) rejects only those samples in which the deviation is more than three times the probable error. Further, there is no unanimity regarding the minimum size of an 'acceptable' series, some accepting samples as small as 100 persons, others requiring 200, while Haldane (*loc. cit.*) deals chiefly with groups of 2000 or more, and

has pooled smaller series in order to obtain samples of sufficient size for his purposes. Thus it is to be noted that some samples are discounted because of insufficient size, and in spite of their small deviations, while others are discarded because of their large deviations, and in spite of their large size; furthermore, since individual standards differ as to both criteria, some samples will be included by one author, but rejected by another.

The consequences of these individual variations in the choice of material are easily foreseen. The inclusion or exclusion of one or another sample, for one reason or another, can produce marked variations in the resultant interpretations of the serological character of a population. Nor is it possible for an author to be entirely consistent in the application of his own set of rules, since in many areas and among many peoples there is a dearth of information of any kind, and consequently, 'unsatisfactory' material must be included, or the space left blank.

What is the intrinsic significance of these criteria? As regards the formula for the sum of the three gene frequencies, it is predicated on an ideal population, one which is completely stable and homogeneous, and in which there is completely random marriage. It is safe to say that such populations are almost non-existent. In primitive as well as in civilized communities, marriage choices are governed by conventions of varying rigidity. In the tribe, these take the forms of exogamy, endogamy, polygyny, cross-cousin marriage, the levirate, etc. In the higher communities, the conventions are concerned with marriage within the social stratum, the economic level, the religion, or the nationality group.

In addition to such differentials within a single ethnic group, there are those which exist between the differing groups and subgroups within a single national boundary. In many parts of eastern Europe it is common to find such ethnic subgroups living in social, if not physical isolation; it would be futile to expect that $p + q + r$ should total unity when two or more such subgroups are lumped together in the same series. The unacceptably large deviations from unity in many large samples must be due to such social and ethnic heterogeneity more frequently than to errors in technique.

In fact, it is probable that such heterogeneity may be much more common than the blood-group formulae indicate; it is quite possible that a large series having a small deviation may actually be a composite

of two or more unrecognized series having deviations of opposite signs, which by cancelling each other, have imparted a false appearance of homogeneity to the final result.

This is not to minimize the importance of the gene formulae, which have contributed enormously to the understanding of blood-group problems, and without which, indeed, such studies as this one would not be possible. I desire merely to point out that such mathematical expressions are only tools, and are not an end in themselves. Statistical procedures have an important place in the analysis of all data, but they should not be permitted to become fetiches, and to obstruct the very efforts which they were designed to assist. Further, the scarcity and the unequal weight of some of the data makes it undesirable to lean too heavily upon mathematical analyses. In such instances, these become over-refinements, comparable to the calculation to six decimal places of the means of a very small number of anthropometric measurements.

Nor is it intended to discount the possibility or the importance of errors in technique. Not only do such errors occur, but it is not difficult to find in the literature even some errors in simple arithmetic. The essential point is that the mere presence of a large deviation does not in itself constitute proof of errors in technique, and that if a broad enough view is taken, the danger from such 'inconsistent' samples is less than the danger arising from an arbitrary choice of material.

As regards the small size of some samples, little need be said. One must often accept that which exists, or go without. However, such an acceptance need not always be reluctant, since in those countries from which a large number of samples are available, the gene frequencies of the small series usually fall within the range of the data as a whole. Sampling errors are undoubtedly present in many small series; however, it would appear better to accept that risk, rather than to level off the distinctive, and perhaps highly significant characteristics of a small sample by pooling it with another sample from which it differs radically.

For these reasons, I have decided not to exclude from consideration any of the series contained in Boyd's tables. It has appeared preferable to use the data as they were obtained and reported by the investigators, rather than to insist on homogeneity where perhaps none should be expected; I have used small series at their face values rather than to manufacture artificially large ones by pooling two or more small series.

Actually, since only one of the three genes is to be considered in these hundreds of series of European and Asiatic peoples, this method is more valid than might at first appear. The reported values of q are probably just as often too low as they are too high, and in the long run, the picture will be accurate. Better still, its validity is demonstrated by the fact that the results of the comparisons are so clear-cut that it is not likely that they could be disturbed by the application of any of the arbitrary standards in common use.

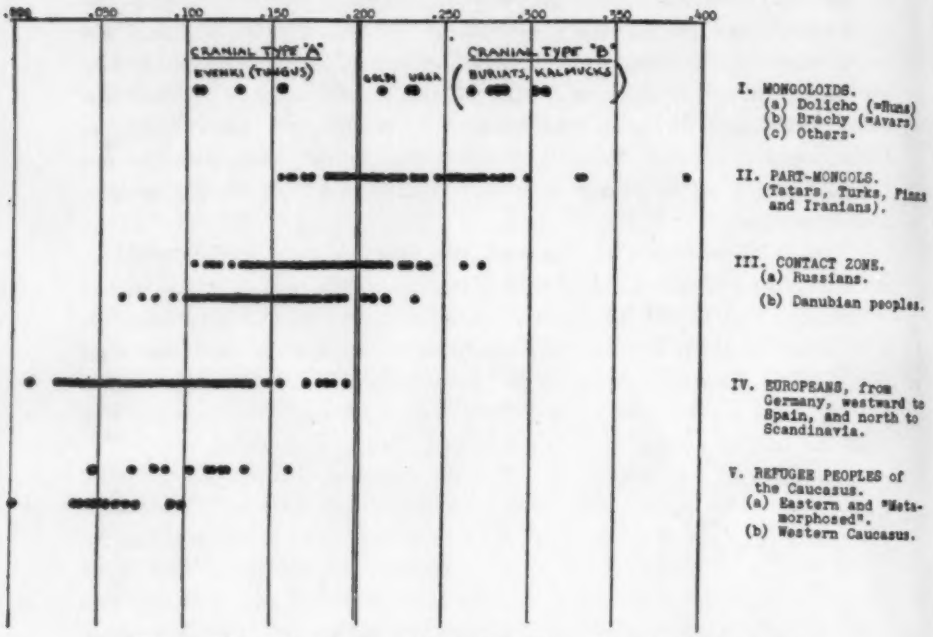

FIG. 1. THE VALUES OF q IN THE FIVE CATEGORIES OF POPULATIONS

COMPARISONS

Fig. 1 has resulted from the plotting of the q values of 749 series, according to their respective positions in the five categories. The number of series in each of the categories is as follows: 13 samples in the 1st Category, 84 in the 2nd, 292 in the two parts of the 3rd, 335 in the 4th, and 25 in the two parts of the 5th Category. Each value was plotted individually; where a number of samples have overlapped, a solid line has resulted. In three of the instances in which

this has occurred, the line includes all but a very few samples; in the 2nd Category, however, the line is more disconnected, reflecting a concomitant ethnic heterogeneity (v.i.).

A q value of .200 has been adopted as a reference point, since this represents a higher frequency of the B-gene than is present in any of the 335 central and western European series of the 4th Category. The sharp progressive decline in the ranges of the values of q is strikingly illustrated by both the maximum and the minimum values in the successive categories, and even the rate of decline tends to be the same at both ends of the ranges.

Where solid lines have resulted from overlapping, these lines follow the same curve; thus in the 2nd Category, the (almost) solid line ranges between .180 and .270, since only 8 or 9 of the 84 samples exceed this maximum value. In the European Russians of the 3rd Category, the main cluster ranges from .130 to .220, while in the other peoples of the same category, it lies between .100 and about .180. In Germany and the more distant peoples of the 4th Category, the solid line extends from about .025 to .140 (see also Fig. 2).

It now remains to discuss the historical and ethnical data relevant to the populations in the five categories, and to see whether the requirements regarding them can be fulfilled.

Requirement No. 1 (pure mongoloids, very high in B). These fall into two main groups: those representing the dolichocephalic Huns, and those descended from, or representative of the brachycephalic Avars. According to the Russian authorities cited by Coon (*loc. cit.*, p. 231), the Hunnish cranial type is found in the modern Tungus and paleasiatics, and is identical with Neolithic crania from Lake Baikal. The blood-group data referable to this ethnic type is far from adequate; however, it is sufficient to indicate a trend toward very high proportions of group O, moderate amounts of group B, and very small amounts of group A.

The term "Tungus" has varying connotations, some linguistic, and others ethnical. Thus, Lopatin ('37) includes the Orochee among the Tungus, while noting some differences from the latter, and in fact, relates the Orochee more directly with the Manchu. Similarly, the Goldi have been classed as Tungus, on a linguistic basis. However, Vishnevsky ('36a) declares that both these tribes and some others should be considered to be Manchu, and that the name "Tungus" should

properly be reserved for the Evenki, whose range extends from the Enesei River to the Pacific, and as far south as Lake Baikal.

Vishnevski (*loc. cit.*) has reported 224 Evenki from this large area, and in these, the percentage of B was 21 per cent, and the q value, .125. Of this total number of 224, Boyd's tables list three of the component series, totalling 145 persons, in whom the values of q vary from .106 to .154 (see footnote No. 6). Thus the Hun = Tungus type of Mongol might be expected to add some B to other populations, but not a great deal. In fact, it would be much more efficient in raising the proportions of group O.

Before proceeding to the second of the two relevant mongoloid types, certain other pure mongoloids of the U.S.S.R. must be considered. These consist of one series of Sungari Goldi, with a q value of .213, and two series of mongols from Urga, with values of .239 and .242 respectively. These three samples are not considered in connection with the main argument, since although Mongols, they are neither Tungus nor Buriats, and therefore are not historically related to the problem at hand. At the same time, it may be of interest to note that the Urga Mongols appear to occupy a position which is intermediate between the Tungus and the Buriats, both as to serology and as to head form. The cephalic indices of the Tungus and the Buriats are given by Bean ('34) as 78.7 and 93.1, respectively, while the series of Urga Mongol crania in the U.S. National Museum are said to have cranial indices averaging 81.4 in the males, and 82.4 in in the females (Cameron, '29).

The brachycephalic mongoloid cranial type found in the Avar graves is said to have been the more numerous of the two, and besides, it was the only cranial type brought in by the armies of Genghis Khan. It is typified by the more pure among the modern Buriats, and by the modern Kalmucks, although in the instance of the latter, the brachycephaly is somewhat less extreme, and the historical association with the later rather than the earlier of the pure mongoloid expansions into Europe.

Five samples of Buriats are listed, totalling 5312 tribesmen. In all five series, the proportions of group B are very high, ranging from 37.5 per cent to 40.8 per cent, and the gene frequencies from .264 to .301. Two of the series, however, are described as "western" and "Irkutsk" Buriats, respectively, while two others are not identified. The more characteristic, and presumably more pure of the Buriats

are to be found in that part of the Buriat-Mongol Republic which lies east and south of Lake Baikal. For this reason, it may be permissible to attach more significance to that series of 1260 Buriats known to have been derived from the Aimak region of the eastern part of the Republic. In these eastern Buriats are to be found the highest proportions of B, the gene frequency being .301, and the actual percentage of group B, 40.8 per cent.

It is interesting to find that the other component of the brachycephalic mongoloid subgroup exhibits almost identical values, in spite of being separated from the Buriats by almost the entire path of invasion. In the Kalmucks west of the Caspian Sea, the gene frequency of group B is .307, representing an actual frequency of 40.6 per cent.

It should be noted that although the Buriats and the Kalmucks are the purest representatives of the brachycephalic mongoloid invaders, nevertheless they are not unmixed. The former exhibit regional variations in their physical characteristics, while the latter must, according to Coon (*loc. cit.*, p. 583), have mixed to some extent with the Russians and Tatars. This does not mean, however, that they could have acquired their B through admixture. The proportions of group B in the Buriat and Kalmuck tribes are the highest in all Asia,[5] and close to the highest in the world. Thus, admixture could only have *diminished* and could not have increased their group B, since, in the light of present knowledge, no Asiatic people could have contributed to such an increase. It appears likely, therefore, that these brachycephalic mongoloids of the U.S.S.R. may once have had even higher proportions of group B than they now possess; however, it is evident that even without this possibility, they fulfill the first requirement in a most satisfactory manner.

Requirements No. 2 (partly mongolized non-Europeans), and *No. 3 (Europeans of the contact zone.)* These are most conveniently considered together, by means of a direct comparison of the frequencies

[5] No Asiatic population is as consistently high in B as are the Buriats. Outside of the U.S.S.R., and aside from the Ainu, there are only three samples in all Asia in which the *q* value is .300 or over. One of the 38 Chinese series, and two of the 39 series from India fall into the .300+ column. The Hindus and the Koreans are well represented in the next lower range; however, the Chinese, who are closest to the Mongol homeland, are relatively low in B, since 63 per cent of their series have *q* values of less than .200. In contrast, four of the Buriat samples fall between .250 and .299, while the fifth and most characteristic series occupies the .300+ column, together with the Kalmuck sample.

TABLE 1

Comparison of the range of values of q in the pure mongoloids of the U.S.S.R. (Category I.)

NAME	NUMBER OF SAMPLES	UNDER .200	.200-.249	.250-.299	.300 OR MORE
Representatives of Huns					
Tungus (Evenki)[6]	4	****	....	....	....
Representatives of Avars					
Buriats, S. & E. of Lake Baikal	1	....	....	....	*
Kalmucks	1	....	....	....	*
All other Buriats	4	....	....	****	....
Other Mongols					
Sunigari-Goldi	1	....	*	....	....
Mongols, Urga	2	....	**	....	....

[6] Boyd's tables list three series, comprising 145 of Vishnevsky's 224 Evenki. The remaining 79 have a q value of .106, and have been rendered as a fourth series (Fig. 1).

of q in the two categories of populations. The contact zone included all of eastern Europe, as far as the borders of Saxony. However, since the proportions of B in Hungary, Poland and Bulgaria are somewhat lower than those of European Russians, it is perhaps desirable to limit the main discussion to Russia alone, since in that country, the two categories of peoples are in relatively closer association, and the differences between them consequently more significant. It will be recognized that this limitation is not prejudicial, but rather the reverse.

There are 145 samples of European Russians listed in the blood-group tables, including those living in Asiatic Russia, and 86 samples described as non-European. This latter figure does not include the peoples of the Caucasus, who will be considered in a separate category, in view of their character as refugee populations. We may now subtract the Kalmuck sample, and the one Buriat sample known to have been derived from the more characteristic Buriat area, since these two series have been chosen to represent the 'pure Mongols, high in B' of the 1st Category.

This leaves in the 2nd Category some 84 series of non-European Russians, including the various Turko-Mongols, Turkicized Finns,

Finnish and Iranian peoples, and the remaining mongoloid groups. Since it is believed that the ultimate source of group B is to be sought in the Mongol and the strongly mongolized populations, it would be permissible to remove from this category the Finnish and Iranian tribes of the U.S.S.R., and to class them with the 'white' peoples of the 3rd Category, who are thought to have obtained their B from the mongoloids. However, since we have chosen to distinguish simply between 'European' and 'non-European' populations within Russia, these essentially non-mongoloid tribes will be included in the broad category of the part-mongolized peoples. And since the Finnish and Iranian tribes tend to have lower proportions of group B than the descendants of the actual invaders, it is clear that in so grouping them, we are being more than fair, and that the results are for that reason all the more convincing.

TABLE 2

Comparison of the ranges of values of q in the 2nd and 3d Categories

CATEGORY	NUMBER OF SAMPLES	UNDER .200	.200-.249	.250-.299	.300+	PER-CENT OVER .200	PER-CENT OVER .250	PER-CENT OVER .300
II. Non-European tribes of the U.S.S.R.	84	18	34	29	3	78.6	(38.4)	(3.5)
III. European Russians	145	124	19	2	..	14.5	(1.4)	.....

When the 84 non-European and the 145 European series are compared with regard to their values of q, it is elicited by actual count that in the former (2nd Category), the value of q attains or exceeds .200 in 66 of the 84 samples, or in 78.6 per cent of the total number. Among the European Russians (3d Category), $q = .200$ or more in only 21 of the 145 series, or in 14.5 per cent (Table 2).

Among the part-Mongols, 38.4 per cent of the total number reach or exceed .250, while only two European Russian samples (1.4 per cent) are within this range. Three of the non-European series are over the .300 mark (in addition to the Buriat and Kalmuck check samples), while none of the European Russians even reaches .300. Thus it is clear that even with the inclusion of the fundamentally non-mongoloid Finns and Iranians having lesser amounts of B, the non-European peoples of the U.S.S.R. possess the B factor in proportions vastly in

excess of those Europeans who are living in the closest contact with them at the present time.

Some comment is due regarding the fact that three samples in the part-mongol 2nd Category exhibit q values which are actually higher than those of the Buriat and Kalmuck check samples (Fig. 1). Two of the three samples are small enough that the anomaly may be ascribed to sampling, since one of them consists of 66 Uzbeks, and the other of 53 Tajiks. The third sample comprises 150 Cheremiss, and while this is still a small series compared to the Buriat sample of 1260, nevertheless it is worthy of somewhat more consideration than the other two.

The possibility that the brachycephalic mongols may once have had even higher proportions of B than they now possess has already been discussed (v.s.). Since the Cheremiss are described as the most strongly mongolized of the Russian Finns (v.i.), it may be possible that a q value of .391 represents a freak survival of the old Mongol frequencies. It is also possible, of course, that the series is composed of several closely related families high in B, and to that extent, a sampling error may have occurred. In any case, the comparisons shown in Table 2 are evidence of the complete fulfillment of the 2nd and 3d requirements.

Additional observations may be made regarding the peoples of the contact zone from an inspection of Table 3. Here it is to be noted that there are some significant differences among the European Russians. The Ukrainians have much more B than the White Russians, as might be expected from the former's having mixed with the Turks and Tatars within recent times. The White Russians are found in the .100-.149 column, as are also the three series of Lithuanians listed by Boyd (*loc. cit.*). This fits with Coon's statement that there is a close resemblance between the two, if not indeed, identity (Coon, *loc. cit.*, p. 568). The highest proportions of B are found in those European Russians who live in Asiatic Russia, in the closest proximity to the non-European peoples, as in Perm and Ksyl-Orda, although some of the Moscow series are high in B.

Poland resembles the 'Hungarians' and the Ukrainians in the distributions of the q values. This is in correspondence with expectations arising out of the historical considerations. In Hungary, the highest q values are found in the Magyars; here again there is correspondence with the ethno-historical considerations, since the Magyars are the

TABLE 3

Values of q in countries in or near the contact zone (3d category)

TABLE 3

Values of q in countries in or near the contact zone (3d category)

COUNTRY	.000-.049	.050-.099	.100-.149	.150-.199	.200-.249	.250-.299	.300-.399
Russia, 145 series							
White Russians, 3	.....	.....	(3)	.....	.....	.....	.....
Ukrainians, 13	.....	.....	30.8%(4)	61.5%(8)	7.7%(1)	.....	.....
Great Russians, 2	.....	.....	.....	(2)	.....	.....	.....
'Russians' in European and Asiatic Russia, 127 series	.....	.....	17.3%(22)	66.8%(85)	14.2%(18)	1.6%(2)	.....
Hungary, 25 series							
Magyars, 7	.....	.....	.....	57.1%(4)	42.9%(3)	.....	.....
Debreczen, 3	.....	.....	(1)	(1)	(1)	.....	.....
'Hungarians', 6	.....	.....	33.3%(2)	66.7%(4)	.....	.....	.....
Budapest, 4	.....	.....	75.0%(3)	25.0%(1)	.....	.....	.....
Others, 5	.....	.....	60.0%(3)	40.0%(2)	.....	.....	.....
Poland, 20 series	.....	.....	35.0%(7)	65.0%(13)	.....	.....	.....
Yugoslavia, 22 series							
Serbs, 7	.....	.....	42.9%(3)	57.1%(4)	.....	.....	.....
Ruthenians, 1	.....	.....	.....	(1)	.....	.....	.....
Schokatzen, 2	.....	.....	(1)	(1)	.....	.....	.....
Slovaks, 1	.....	.....	(1)	.....	.....	.....	.....
Unspecified, 11	.....	18.2%(2)	63.6%(7)	9.1%(1)	9.1%(1)	.....	.....
Finland, 64 series	.....	.....	67.2%(43)	31.2%(20)	1.6%(1)	.....	.....
Roumania, 15 series							
Sséklers (Hungarian), 3	.....	.....	(2)	(1)	.....	.....	.....
'Roumanians', 12	.....	.....	91.7%(11)	8.3%(1)	.....	.....	.....
Bulgaria, 6 series	.....	.....	(6)	.....	.....	.....	.....
Czechoslovakia, 10 series							
Ruthenians, 1	.....	.....	.....	(1)	.....	.....	.....
Slovaks, 2	.....	.....	(2)	.....	.....	.....	.....
Czechs, 3	.....	(2)	(1)	.....	.....	.....	.....
Unspecified, 4	.....	.....	(4)	.....	.....	.....	.....

lineal descendants of the Turkified invaders of the 9th century, and some of them even claim descent from mongoloids (v.i.).

The Finns in Finland have somewhat less B than the Hungarians, to whom they are related by language ties, and less than the Finnish tribes in Asiatic Russia. Bulgaria's place in the table is surprising at first glance; however, the low proportions of B in Bulgaria are explained by the historical facts. The ancient Bolgars who settled that country were Turkified Finns, and in any case their numbers were not great. Several of the Slavic series exhibit very little B. This is particularly true in Yugoslavia and Czechoslovakia. Of the three Czech samples, for example, two contain q values under .100, while the third is under .150.

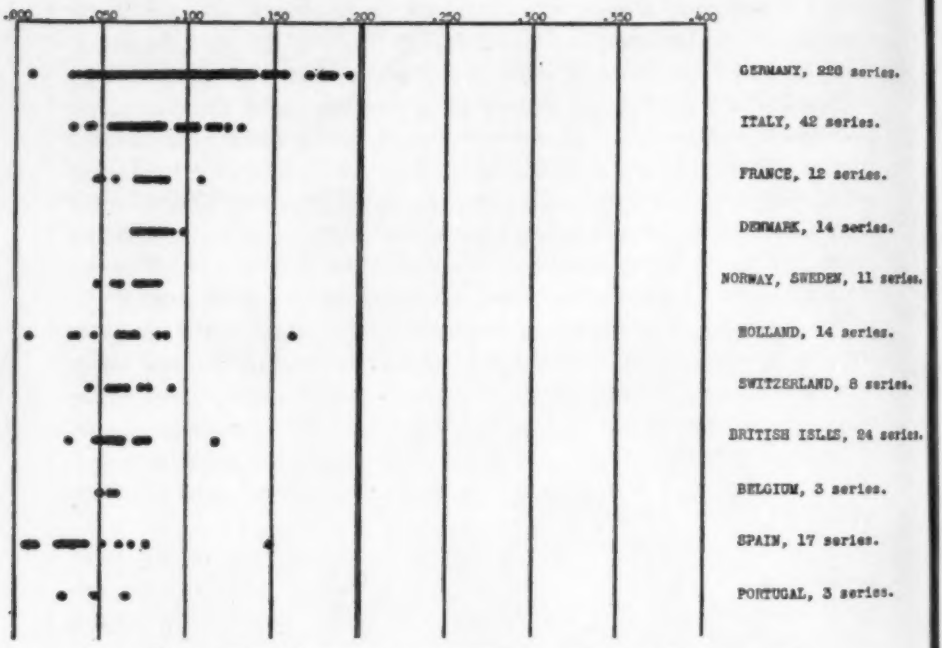

FIG. 2. THE VALUES OF q IN THE POPULATIONS OF CATEGORY IV

Requirement No. 4 (populations geographically remote). Little time need be expended in demonstrating that the further one proceeds westward from the zone of invasion, the smaller become the amounts of group B in the respective populations. Fig. 2 represents the actual q values of most of the countries in the 4th Category; those countries

which have been omitted fall into the range of values of the category as a whole (see Fig. 1). It is evident at a glance that the q values diminish as the distance from the contact zone increases, and that the entries tend to become more and more concentrated in the columns for the lower values of q. The lowest proportions of group B are found in Spain and Portugal, where 12 of the 20 series contain q values of less than .050.

The striking difference between the sample from Valladolid and the 16 other Spanish series has been remarked by Haldane ('41). Its q value of .149 is higher than those found in any population of the 4th Category except Germany, and one of the Dutch series. Valladolid was the meeting place of the cortes of Castile between the 11th and the 16th centuries, and its university dates from about 1250 A.D. (*Encyclopaedia Britannica,* '37). It is doubtful, however, that the unexpectedly high value of q can be related to these cosmopolitan features in the past history of Valladolid, since Haldane states that the material consists of soldiers and students drawn from a large part of central Spain. At the same time, it is probably unsafe to accept Haldane's *a priori* conclusion that the findings may have resulted from serious errors in technique, since further researches may eventually reveal some other explanation.[7] At any rate, the Valladolid series cannot be said to disturb the established trend to any great extent.

In his book, *The Races of Europe,* Coon presents the evidence for his belief that in some of the northern parts of Europe there is a survival or a re-emergence of Upper Paleolithic man. The ethnic types most representative of such survivals or re-emergences are found in Iceland, western Ireland, the coast of Holland, northern Germany, Belgium, and in some parts of Scandinavia. The Lapps are also related to Upper Paleolithic horizons.

It is at once evident that group B is very scanty in all these populations. Only in the Lapps (and in a single Dutch series) does the q value ever attain or exceed the .100 mark. Even in the Lapps,

[7] The following reference may indicate the direction of such an explanation: 500 Spanish Jews had these blood group frequencies: O: 38.8 percent, A: 33.0 percent, B: 23.2 percent, AB: 5.0 percent (Hirszfeld and Hirszfeld, '19). The q value in this series is .165, comparable to other Sephardic Jews. If it be possible that the 'students and soldiers' of Valladolid may have included a large submerged Jewish element, then the mystery is solved. The migration of Sephardic Jews to Holland in the 16th century may be related to the presence of one exceptionally high q value in that country also.

8 of their 12 series contain values under .100, and four of these are under .050. Thus it seems fair to assume that Paleolithic man in Europe could have contributed very little, if any B.

In fact, if there is anything at all characteristic in the serology of the peoples in the areas designated, it is not in the proportions of B, which do not differ significantly from the rest of western Europe; it is rather in the remarkably high proportions of group O which are present in the more peripheral and the more unmixed among them. Thus, the Icelandic series of 800 persons has the extremely high r value of .747. The r value of Boyd's Irish series is .744; that of Sachs ('41) is .732, and that of Taylor's is .765. Values of r in excess of .700 are also found in many of the series of the other peoples in these areas.

As for the Nordic and Mediterranean 'races', it is equally unlikely that their ancestors could have contributed any B to the European blood group picture. Scandinavia, which is said to have been the breeding ground of the Nordics, and which still contains a large Nordic element, exhibits q values well under .100, as does also Denmark. Germany is well mixed serologically as well as ethnically; however, a great many of the German series have extremely low q values, and among these are the two series of 'Saxons' and the single sample of 'Angles'.

The Mediterranean race, insofar as it is represented in its greatest purity by the Spanish and the Portughese, has already been shown to have the lowest proportions of group B in Europe (Fig. 2). The Alpine division, represented by the French, is also low in B, since of the 12 French series known to me, only one reaches or exceeds the .100 mark (.109). However, whereas the Nordic and Mediterranean peoples frequently exhibit very high values of p (group A), there is no series in France with p values of .300 or over, except for those derived from Alsace, where German admixture may be assumed.

Thus even a casual survey of the distributions of the three blood group factors reveals the fact that the racial stocks of western Europe differ significantly in their relative proportions of groups O and A, but that all agree in having such small amounts of group B that its presence could be accounted for by diffusion, during the centuries which have elapsed since the Asiatic invasions of eastern Europe first introduced the B factor.

Requirement No. 5 (isolated refugee populations, lowest in B). This requirement is somewhat more difficult of fulfillment, since no sizeable population in the contact zone can be said to have escaped completely from the invaders during the ten centuries of expansion. However, the isolated tribes of the Caucasus mountain ranges constitute a close approach to the ideal refugee population which we seek, and as a matter of fact, the manner of their deviation from the desired purity may even prove illuminating.

There is historical as well as anthropological evidence that their escape was not complete. The former has to do with the periodic incursions into the Caucasus of each of the invading armies, resulting in the flight of the invaded peoples further and further into the mountain fastnesses and the intervening valleys. The present distribution of this refuge area is very restricted; it consists of a narrow strip extending horizontally eastward from the toe of the Black Sea. South of it reside the Armenians and the Turks, while to the north are found Russians on the left, and the Kirghiz Turko-Mongols on the right. A large remnant of true Mongols, represented by the Kalmucks of the 1st Category, is found north of the Kirghiz (Coon, *loc. cit.*, p. 631).

Coon's map of racial distributions indicates that the Caucasic-speaking inhabitants of the refuge area include several pure Mediterranean varieties, as well as some Alpine-Danubian mixtures. Distinct from these, however, are the Ossetes, who are Iranians, and who are believed to be the result of the mixture of Scytho-Sarmatian refugees from the north with the indigenous peoples (Coon, *loc. cit.*, p. 632). The Ossetes are described as possessing many Nordic and Noric characters, and are to be referred historically to the Scythian Alans (*idem*, p. 197).

However, in some of the groups within this area there are strong traces of mongolization, attributable to the Asiatic inroads. The Lesghians, for example, range from frankly mongoloid types at one extreme, to pure whites at the other. It is also to be noted that one of the Lesghian tribes calls itself "Avars" (*Encyclopaedia Britannica*, '37a).

Semenskaya divides the Caucasian tribes into three classes: 1. Eastern; 2. Metamorphosed; 3. Western (Boyd, *loc. cit.*). It is significant that the Ossetes, who are in many respects closest to the Nordic physical type, are included with the Lesghians in the 'Metamor-

TABLE 4

Values of q in the refugee populations of the Caucasus (5th Category)

NAME	NUMBER OF SERIES	.000-.049	.050-.099	.100-.149	.150-.199	.200-.249	.250-.299	.300-.349
Eastern Group								
Kakhetintsi	2	..	..	*	*	..	..	..
Tushini	1	..	..	*	..	..	..	..
Kartalintsi	3	..	**	*	..	..	..	..
Mokhevtsi	1	..	*	..	..	..	..	..
"Metamorphosed" group								
Lesghians	1	..	..	*	..	..	..	..
Ossetes	4	*	..	***	..	..	..	..
Western Group								
Rachintsi	1	..	*	..	..	..	..	..
Guritsi	3	*	**	..	..	..	..	..
Imeritini	3	*	**	..	..	..	..	..
Mingreltsi	3	*	**	..	..	..	..	..
Swanetes	2	*	*	..	..	..	..	..
Adhartsi	1	*	..	..	..	..	..	..

phosed' class. Correspondingly, four of the five series in this class contain q values in excess of .100. The Eastern Caucasic tribes include three samples which are under .100, as well as one which exceeds .150. However, it is important to note that not one of the 25 series in Semenskaya's three classes contains a q value as high as .200 (Table 4).

Three other series are listed from the Caucasus region; one consists of Turks, who are considered together with other Turks (v.i.), while two samples of Ingushetes exhibit values in the .100-.149 column.

The Western group of tribes is of the greatest interest in connection with the present argument. It contains 13 series, totalling over 10,000 persons. In none of the samples does the q value reach even .100; in five samples the value is less than .050, and in one small series of Mingreltsi, AB was found, but no individuals of group B. These findings are all the more striking when it is remembered that in their almost complete lack of the B factor, they are rivalled only by the Basques, and that while the latter are distant by an entire continent from the scene of invasion, these Caucasian tribes are practically within the contact zone.

Thus, insofar as the Western Caucasic peoples may be accepted to be representative of a relatively pure refugee population, there seems to be sufficient evidence that these early inhabitants of the contact zone were lacking in B anterior to the arrival of the Asiatic armies; that such small amounts of B as they now possess may be ascribed to mongoloid or Turko-Tatar admixture, and that for them, at least, the 5th requirement is fulfilled.

NON-EUROPEAN POPULATIONS OF THE U.S.S.R.

Now that the requirements which were set up in connection with the five broad categories of populations have been considered, and, it is thought, fulfilled, it may be of interest to investigate one of them more fully. Since the 2nd Category consists of a heterogeneous assortment of peoples of widely divergent origins, it should be possible to apply the same criteria to its component tribes, and to demonstrate in them a correlation between the degree of mongolization and the respective proportions of group B.[8]

It is most gratifying to find that such a correlation is plainly discernible. This is in spite of the fact that the data is somewhat defective as to some of the elements of each of the sub-categories. There are no data available, for example, regarding the blood group frequencies in the Yenesseian Ostyaks, Chukchi, Yukaghir, etc., nor in the Finnish Voguls and Ostiaks who migrated to the Ob region, nor in the mongoloid Samoyedes, who represent the Buriat-Mongols on European soil. Further, none of the data can be said to have been collected with a view to making a systematic correlation possible.

The non-European populations of the U.S.S.R. may be classified under three main headings (apart from the true mongoloids of the 1st Category, and the Caucasic tribes of the 5th): 1. Iranians; 2. Finns; 3. Turko-Tatars. All of them have been subjected to some mongolization, varying in degree from relatively little in the Iranians and some Finns, to such a high degree in some of the Turko-Tatar tribes that the appellation "Turko-Mongol" becomes more appropriate. All of them possess significantly large amounts of group B, so that

[8] It should be clear that there is no implication of a correlation between the physical traits of an *individual* and his blood group. There is no genetic justification for such a premise. The equation is between the tribal distributions of mongoloid traits and of the B factor.

the term, "low in B", as applied to members of the 2nd Category, must be recognized to have only a relative meaning.

The revelant values of q are shown in Table 5, in which the subcategories and the tribes within each of them are listed, roughly in the order of their q values. While space does not permit a completely documented discussion of each of the peoples listed therein, nevertheless it is possible to summarize a sufficient amount of the data given by Coon (*loc. cit.*) to establish the presence of a considerable degree of correlation.

The Iranian Ossetes (of the 5th Category, included here for the sake of completeness) are described as Scytho-Sarmatians from the

TABLE 5

Comparison of the range of values of q in the non-European populations of the U.S.S.R. (Category II)

NAME	NUMBER OF SAMPLES	UNDER .200	.200-.249	.250-.299	.300+
Iranians					
Ossetes[9]	4	****	....	....	....
Tajiks	6	****	*	....	*
Finns					
Zyrians	1	*	....	....	....
Carelians	1	*	....	....	....
Votiak	10	****	*****	*	....
Permiaks	5	....	****	*	....
Cheremiss (Mari)	2	....	....	*	*
Turkified Finns					
Bashkir	1	*	....	....	....
Chuvash	5	....	**	***	....
Turko-Tatar-Mongols					
Tiurks	2	*	*	....	....
Kara-Kalpacks	1	....	*	....	....
Turkomans	1	....	*	....	....
Kazaks	5	*	**	**	....
Tatars	7	....	*****	**	....
Uzbeks	7	*	***	**	*
Kipchaks	1	....	....	*	....
Kirghiz	12	....	**	***** *****	....

[9] From the 5th Category, included for comparison with the Tajiks.

northern plains. Although enough admixture is present to justify their inclusion in the "metamorphosed" class of Caucasian inhabitants, they exhibit fundamentally Nordic characteristics. The Ossetes are clearly the least mongolized of the ethnic groups under present discussion; correspondingly, all four of their blood-group samples have *q* values which are not only less than .200, but well under .150.

The Iranian Tajiks are described as typical Alpines, resembling Frenchmen and southern Germans; nevertheless, a small amount of mongoloid admixture is present in some of their tribal groups (Coon, *loc. cit.*, p. 638). Four of the six Tajik series exhibit *q* values under .200; it may be that the remaining two samples are associated with the greater degrees of mongolization in some areas. At any rate, as regards their position in the 2nd Category, the Tajiks must be classed as 'non-mongoloids, low in B'.

The Finns present a more complex problem, in that there are wide geographical variations, but only small physical differences among them. To a considerable extent, however, these physical variations will be found to correspond to the variations in the values of the B-gene. Thus, the Carelians are said to be representative of the Iron Age Nordic physical type, and to include only a lesser mongoloid element (Coon, *loc. cit.*, p. 344). The physical characteristics of the Zyrians appear to correspond closely to those of the Carelians (*idem*, pp. 342 and 349), and it is significant that the single series of Carelians and of Zyrians both exhibit *q* values which are less than .200.

The Votiaks are represented by ten series, of which four contain values under .200. Five samples exhibit values between .200 and .249, while the tenth series lies between .250 and .299. Coon (p. 348) describes an appreciable amount of rufosity, and believes the Votiaks to be not appreciably more mongoloid than the Mordvins and Cheremiss (however, see below). Nevertheless, from their deficiency of body hair, and the predominance of straight head hair and darker pigmentation, it seems fair to infer that the Votiaks must at least be more mongoloid than the Nordic Carelians.

The Permiaks resemble the Votiaks in their physical characteristics, lacking, however, the latter's rufosity. Of the five Permiak samples, four are found in the .200-.249 column, and the fifth between .250 and .299. Thus the Permiaks possess more B than the foregoing tribes, but apart from the difference in hair color, there are no ethnic or historical data which might permit a clear interpretation.

The Cheremiss, on the other hand, are described as having been recognizably affected by Mongol and Tatar infiltration. This is evidenced by very high frequencies of the median eye fold, dark pigmentation, weak beard growth, and concavity of the nasal profile (*idem*, p. 347). These are clearly the most highly mongolized of all the Finns of the U.S.S.R.; concomitantly, they possess the highest proportions of group B, with q values in the .250-.299 and the .300+ columns.

Thus it is apparent that within the limits of the published serological and anthropological data, the proportions of group B in the Finns increase apace with the evidences of mongolization. A perfect correlation is not possible, since there are many gaps and imperfections in the data. In addition to the deficiencies already listed, it would be of interest to know the blood groups of the "Forest" Cheremiss, who are non-mongoloid, and are said to be closest to the Carelian Nordic type (p. 347). Among the mixed and variable Votiaks, it would be advantageous to segregate the blood-group data with an eye to the varying degrees of mongolization. However, even within the limits of the available information, it appears that in the Finns, who are characterized by Coon as ". . . . all very much alike", the relatively minor differences which exist are clearly reflected in the gene values for group B.

The Turkicized Finns are represented in the blood-group tables by the Bashkir and the Chuvash. These two tribes illustrate clearly the difference between turkicization and mongolization. The Bashkir, in spite of their dark pigmentation, exhibit (Turk-like) convex noses in 15 per cent of their number, but no mongoloid nasal form (*idem*, p. 579). Their blood group distributions, as represented by a single series, contain a relatively low q value, just under .200. Thus the Bashkir are seen to be actually less mongoloid, both as to physical type and as to serology, than the Cheremiss, who are classified as Finns.

The Chuvash, on the other hand, although very variable, exhibit definite mongoloid traits as a result of Tatar admixture (*idem*, p. 578). The mongoloid characters are accompanied by correspondingly larger amounts of group B, since two of their five series are to be found in the column $q = .200\text{-}.249$, and the remaining three in the column $q = .250\text{-}.299$. These differences between the two varieties of Turkicized Finns constitute impressive evidence that the Asiatic "Turks" who accompanied the Mongols were themselves very variable in their

respective degrees of mongolization, and concomitantly, in their proportions of group B.

The partially mongolized peoples variously known as Asiatic Turks, Tatars and Turko-Mongols constitute the most difficult problem of all. This is not surprising, in view of the complexity and the long duration of the mixing process which occurred before, during, and after the ten centuries of periodic expansion. This mixing process involved the pre-historic white peoples of central Asia (some of them blonde), the pre-historic and the historic central Asiatic Turks, and at least two distinct varieties of pure mongoloids. One of these appears to have had very high proportions of group B, while the other had very little, or perhaps, in the beginning, even none.

In spite of this complexity, and of the uneven value of the blood-group data, a certain degree of parallelism can be demonstrated. Thus, the Azerbajian Turks of the Caucasus and the Turkomans are described as almost pure whites. However, some mongoloid traits are present in both, and these are more strongly marked in the Turkomans (Coon, *loc. cit.*, p. 424). Their blood groups, insofar as they are represented by the published data, agree with this characterization, since the Turks of the Caucasus have a q value of only .163, while that of the Turkomans is .208. The single series of Turks from Andizhan may reasonably be thought, from its geographical position, to have had more opportunity to absorb Asiatic blood; at any rate, its q value is somewhat higher (.225). The Kazaks are spread over three columns, while the related Kara-Kalpacks, represented by one small series, is found a little below the mean of the Kazak values.

The Uzbeks furnish a measure of correlation, manifested, however, in their marked variability. In their physical characteristics, they are said to run the gamut from pure white, or almost pure white individuals, to others who are apparently pure mongoloids (Coon, *loc. cit.*, p. 635). The more mongoloid of the Uzbeks are chiefly those in the clan divisions, while those outside the clans are more frequently European in habitus (Vishnevsky, '36). Their blood groups also cover the entire range of variability, since the seven Uzbek samples contain values in all four columns, corresponding to the Iranian frequencies at one extreme, and the Kalmuck and Buriat frequencies at the other. Here, as in the instance of the Votiak Finns, it would be more satisfying to have the blood-group data divided with regard to the local physical differences within the Uzbek tribes.

Under the generic name of "Tatars" are included several widely differing groups of tribes; however, both the Tatars and the Kirghiz are listed as "Turko-Mongols", and are unquestionably the most strongly mongolized of all the mixed populations under present discussion. The Kipchaks are more or less pure mongoloids of the later invasions, being associated with the period following Genghis Khan. As expected, the Kipchaks, Tatars and Kirghiz all have large amounts of B, the most consistently high values being present in the Kirghiz (Table 5).

In summary, not only does the 2nd Category as a whole illustrate the close relationship between the extent of mongoloid admixture and the frequency of the B factor, but also its sub-categories, and even the individual tribes within the sub-categories all lend support to that major premise. It is important to note, however, that regardless of their proportions of B, brachycephaly is the rule in this category of populations. Furthermore, if the skeletal material is to be credited, these tribes have always been brachycephalic (v.s.). It is highly probable that in providing eastern Europe with its group B, these mixed Asiatic-white invaders must also have contributed an even greater increment to its brachycephaly. Consequently, it is not surprising that the white populations now living in this area should in their turn be more uniform in their head shape than in their proportions of the B factor.

DISCUSSION

As far as we have gone, it has been possible to demonstrate that the larger amounts of group B are found in the brachycephalic mongols, and, in progressively diminishing amounts, in their partly mongolized allies, and in the European peoples of the contact zone. This would seem to establish the *source* of group B, but something more is needed if we are to decide the *time* of its introduction into Europe.

It may be superfluous to point out that the acceptance of the proposed derivation of group B from brachycephalic mongoloids carries no implications as to the presence or absence of a significantly large mongoloid element in the ancestry of a group B European. The A and B factors are inherited as Mendelian dominants, and are not known to be linked genetically to any physical or physiological character; consequently, decisions as to racial origins cannot be predicated upon the blood groups alone, but must be traced with the concurrent assistance of all the disciplines.

The peoples of the contact zone are not appreciably mongoloid, in spite of historical evidences of actual intermarriage over a period of several centuries. Russia exhibits the strongest traces of mongolization, while in Hungary, the recognizably mongoloid traits are present in only 5 per cent of the population, and are found chiefly in the rural Magyars. Some of these trace their ancestry to the Avars themselves, rather than to the armies of Árpad. However, in 20 per cent, and chiefly in the nobility, Turkish blood is said to be in evidence (Coon, *loc. cit.*, pp. 584, 586).

Conversely, the absence of group B in an individual does not in itself rule out even a strongly mongolized ancestry, since even in the Buriats and Kalmucks, only about 50 per cent belong to groups B and AB, and only that proportion could transmit the B factor to their offspring. The tribes of the 2nd Category have in general lesser amounts, even in the more strongly mongolized groups.

Since the presence of group B in an individual does not in itself imply a significant degree of mongolization, and its absence does not exclude it, what, then, is the significance of the correlations which have been demonstrated in the Siberian tribes? The answer to this question lies in the difference between the mechanisms by which the two sets of characters are inherited. It is obvious that if the B factor and the 'mongoloid' physical status were completely linked genetically, then, generally speaking, every B individual would be a mongoloid. Even in the absence of linkage, if each of the two characters were transmitted by a single gene, then we should expect to find recognizable mongoloid types in all parts of Europe. This, however, is not the case.

The 'mongoloid' habitus is not a single character; it is made up of a complex of physical traits. It is only when an appreciable number of these traits are combined in one individual that a 'mongoloid' emerges as a physical type. This complex of traits is not inherited *in toto*, as a unit character, but is dependent upon the collective action of a large number of genes. Following the introduction of these genes into a new population, the process of independent assortment would gradually but inevitably effect the disappearance of the mongoloid habitus in the subsequent generations. If, however, the increment of mongoloid admixture were very large, or, alternatively, if the continued influx of newcomers were to permit a significant amount of

crossing back to the mongoloid stock, then a recognizable mongoloid element could be expected to persist in the invaded population.[10]

In the instance of the blood group factors (including the M-N and the Rh complexes), the mechanism is entirely different. These factors are transmitted as unit characters, by single genes. If they appear at all in the offspring, they appear *in toto,* and are so transmitted to subsequent generations. Therefore, it is theoretically possible for an individual of group B to have had only one Asiatic ancestor in the past fourteen centuries, and if that ancestor was a mongol-white cross, then the ultimate pure mongoloid source of his B factor could be much older.

It is considerations such as these which have prompted Shanklin ('36) to remark, in another connection, that "the serology was much more susceptible to foreign influence than the somatology of the group". In consequence, it is only natural that even the European populations in the contact zone should show only occasional traces of mongolization, and those more distant, none at all.

The tribes of the 2nd Category constitute the crux of this argument. The fact that they exhibit recognizable mongoloid traits in some of their groups, and the fact that the presence of these traits is rather closely correlated with the higher proportions of group B must be explainable by the combined effect of two considerations. The first of these is the fact that they absorbed much larger increments of mongoloid blood from their Mongol allies and overlords than they were able to pass on to the peoples of Europe. The second consideration has to do with the relatively short time which has elapsed since they mixed with the mongols in Asia and along the line of march. For it is obvious that in peoples who have absorbed a large increment of foreign blood, a longer period of time will be required to assimilate and digest the serological and somatological differences, than in those in whom the increment was smaller.

This is all the more true in the present instance, in which the new (mongoloid) traits appear to be to some extent genetically dominant (Tao, '35). Presumably the period of time which has elapsed since the era of the mongoloid invasions has sufficed to obliterate such correlations as may once have existed in Hungarians, Poles and Russians;

[10] It is assumed that the Tatars and the Turko-Mongols must have retained their strongly mongoloid characters by virtue of their long association with the Mongols on the central Asiatic plains, and along the path of conquest.

certainly it has not sufficed in the instance of the mongol-white mixtures of the U.S.S.R. It is the continued existence of these correlations which points not only to the source of Europe's group B, but also to the time of its introduction.

As for the European peoples of the contact zone, the serological picture has been rendered less self-evident by the events which have transpired since the end of the Asiatic invasions. When full account is taken of these historical factors, the proportions of group B in eastern Europe become more intelligible. And if the amounts of B in some of these populations do not appear as large as might at first be anticipated, it must be recalled that with the eastward Slavic push in the 16th and succeeding centuries, many of the mongoloid and mongolized elements were forced out of Europe, leaving only scattered settlements behind. The subsequent alternating Germanic and Slavic expansions have served to soften, and often to obliterate the lines of serological demarcation between the invaded parts of Europe and those further west. The same period of time has sufficed to spread the B factor westward in progressively diminishing proportions, reaching a low ebb in Spain and Portugal. However, at the zone of contact between the European and the Asiatic peoples, the history of group B is clearly written.

SUMMARY

Although it is generally conceded that the European populations obtained their group B from Asia, there appear to be no indications in the literature as to the time of its arrival, nor as to the identity of the peoples who brought it. In an attempt to decide these questions, the historical and ethnical data regarding five categories of populations have been correlated with their respective proportions of group B.

The categories are the following: I. The modern representatives and descendants of the pure mongoloid invaders of the 5th, 6th and 13th centuries; II. The descendants of the mixed Turko-Tatar-Mongols who accompanied the Mongols, and who chiefly affected the actual occupation of the invaded areas; III. The Europeans now living in closest contact with the peoples of the first two categories, and who were most affected by the invasions; IV. The Europeans who are geographically remote from the zone of contact; V. The isolated descendants of the refugees from the Asiatic invaders.

These comparisons demonstrate that the brachycephalic element among the mongoloids of the 1st Category possess the highest proportions of group B of any of the populations of the continent of Asia, and that the proportions of B are progressively smaller in each of the succeeding categories, regardless of geographical location. Further, some of the smaller subgroups, and even the individual tribes within those subgroups all exhibit a close relationship between the degree of mongolization and the amount of group B.

These findings appear to justify the conclusion that group B was brought into Europe by the brachycephalic Asiatic armies between the 5th and the 15th centuries, since if its introduction had been more ancient, such close correlations would not now be demonstrable.

The fact that the part-mongol elements of those armies, while possessing widely varying amounts of B, were nevertheless all brachycephalic, may serve to explain the lack of correlation between head form and blood groups in eastern Europe. The results of these studies illustrate the necessity of combining the historical and ethnical considerations with the analysis of the blood group data, rather than to attempt to interpret the latter from their purely geographical distributions.

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SKELETAL PROPORTIONS OF ADULT LANGURS AND MACAQUES[1]

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INTRODUCTION

KNOWLEDGE of man's place in nature depends on the results of comparative studies of men, apes, and monkeys. Of these groups man has been the primary object of investigation. In recent years, largely through the publications of Schultz, understanding of the great apes and gibbons has been greatly expanded. At the present time there exists no comparable body of data concerning the proportions of monkeys. To evaluate the evolutionary significance of the proportions of the higher catarrhines (gibbons, great apes, and man) more information about the proportions of the lower catarrhines (the Old World monkeys) is necessary.

Macaques are common in many laboratories, and their near relatives (the guenons, mangabeys, and baboons) are inhabitants of nearly every zoological garden. Therefore, they have frequently been studied by the comparative anatomist. Recently the fetal growth of the macaque has been investigated by Schultz, and an anatomy of the rhesus macaque, edited by Hartman and Straus, has appeared. The section of Mollison's treatise on the proportions of primates which deals with Old World monkeys is largely a study of the macaque-like monkeys.

The macaques and their relatives are classified as a sub-family of the Old World monkeys, known as the Cercopithecinae. Many of the current generalizations concerning monkeys, particularly in the anthropological literature, apply only to this sub-family.

[1] This paper is a condensed version of a thesis submitted to Harvard University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The other sub-family of Old World monkeys, the Semnopithecinae, is composed of the Asiatic langurs, or leaf-monkeys, and the African guerezas (*Colobus*) monkeys. The Semnopithecinae are specialized leaf and fruit eaters. They do not thrive in zoological gardens. They are not used as laboratory animals. Therefore, they have been less available for investigation and have been studied far less than the macaques and their relatives.

The Asiatic Primate Expedition (a cooperative undertaking of Columbia, Harvard, and Johns Hopkins Universities) collected three series of monkeys in British North Borneo. Two of these series consisted of langurs and one of macaques. This collection afforded an opportunity to supplement existing information by extending knowledge of the proportions of Old World monkeys, and particularly of the langurs.

The purpose of this paper is to compare these langurs and macaques, and to ascertain to what extent existing generalizations concerning Old World monkeys would be changed if langurs, rather than macaques, formed the basis for these generalizations.

Since the ultimate aim of studies such as this is a more precise definition of man's place in nature, frequent comparisons with the higher catarrhines will be made, and a method of simplifying comparisons of the higher and lower catarrhines will be discussed.

A travelling fellowship from the Sheldon Fund of Harvard University made possible the author's participation in the Asiatic Primate Expedition. The author wishes to express his indebtedness to Mr. H. J. Coolidge, Jr., organizer of the expedition, to the Museum of Comparative Zoology of Harvard University for the loan of the collection upon which this study is based, to Drs. A. H. Schultz and E. A. Hooton for their help and interest.

A total of 98 complete skeletons of adult monkeys form the basis for this study. The measuring technique used is that described by Schultz (1929, 1930, 1933a, and 1937) [2].

	Males	*Females*
Macaca irus (crab-eating macaques)	16	12
Trachypithecus pyrrhus cristatus[3] (crested langur)	12	22
Presbytis rubicunda (maroon langur)	19	17

[2] Dr. Schultz demonstrated certain difficult points to the writer.

[3] The names of langurs are those suggested by Pocock in his 1934 revision of the langurs east of the Bay of Bengal.

A brief outline of the order and method of presentation will aid in following the detailed description. Body size is considered first. Then the size and characteristics of the trunk and limb girdles, then the length and proportions of the limbs. Finally, the skull is considered, its relations to body size, and the proportions of braincase and facial skeleton.

In such a study as this two animals may be considered the same if they are of the same size and have the same proportions. Difference may be in size, proportion, or usually, in a combination of both. The conventional indices describe a small number of the proportional differences. To interpret the differences, or similarities in indices, a knowledge of the actual measurements and associated conditions is necessary. For example, the intermembral index of the maroon langurs is within the range of human variation. One can assume at once that this is a case of short limbs happening to give the same index as long limbs. However, the intermembral index of the crested langurs is higher than that of the maroon langurs. Here "common-sense" is no aid in discovering what is responsible for the difference in the index. The actual measurements and additional proportions are needed to show what is taking place.

In order to show why indices vary it is necessary to consider the actual measurements more than is customary in primatology.

Body size

Weight and trunk height (suprasternale to symphysion) are both used as indicators of body size. By both standards the crested and maroon langurs are larger than the macaques. The difference is less in weight than in trunk height.

The magnitude of the sex difference in weight and trunk height is different in all three groups. In weight the males exceed the females in the macaque by 60 percent, in the crested langurs by 16 percent, and in the maroon langurs by 3 percent. Differences in trunk height follow the same trend but are smaller than might be expected from the differences in weight. This is due to a sex difference in trunk height to be discussed below.

Before using trunk height as a comparative standard, it is necessary to analyze the factors upon which it depends. Trunk height is best considered a vertebral measurement plus a pelvic one, taken for con-

TABLE 1

Means and ranges of variations (in parentheses) of the size, spine, sternum, and clavicle discussed in this study

CHARACTER	MACACA IRUS		TRACHYPITHECUS PYRRHUS CRISTATUS		PRESBYTIS RUBICUNDA	
Measurements (mm.) and proportions	*15 males**	*11 females*	*12 males*	*22 females*	*19 males*	*17 females*
Size: Weight in kilograms	4.8(3.9-5.9)	3.0(2.5-3.6)	6.7(5.9-8.0)	5.8(5.2-6.4)	6.2(5.5-7.0)	6.0(5.5-7.0)
Trunk height	304(283-323)	272(253-285)	367(353-383)	357(326-380)	348(327-365)	349(334-376)
Spinal regions: Cervical length	51	43	58	52	55	53
Thoracic length	129	108	158	150	154	151
Lumbar length	135	122	173	170	168	170
Pelvic part of trunk height	40	42	36	37	26	29
Sternum: Number of sternaebrae	6(5-7)	6(6-7)	5(5-6)	5(5-6)	5(5-6)	5(5-6)
Cases of union of sternaebrae	None	None	1	1	6	3
Mid-sagittal division of sternaebrae	None	None	1	2	None	None
Sternum length	72(64-83)	55(52-58)	79(73-87)	70(63-79)	80(72-93)	73(65-83)
Sternum length in % of thoracic length	56	51	50	47	52	48
Manubrium length	18(15-21)	13(12-15)	24(21-30)	19(18-23)	21(18-25)	20(16-23)
Corpus length	54(45-66)	42(39-46)	56(49-63)	51(45-59)	59(52-68)	54(48-60)
Manubrium length in % of corpus length	33(26-40)	32(26-38)	43(37-55)	38(33-45)	36(31-39)	37(31-41)
Corpus breadth	6(5-7)	4(4-5)	9(8-12)	8(7-10)	12(9-14)	11(9-12)
Corpus breadth in % of corpus length	11(9-13)	10(9-13)	17(15-19)	16(13-20)	20(15-24)	20(17-24)
Clavicle: Clavicle length	49(44-55)	39(36-44)	51(46-56)	45(43-49)	51(49-53)	48(45-51)
Clavicle length in % of humerus length	39(35-43)	36(34-38)	36(33-39)	33(31-36)	38(36-40)	36(32-38)
Clavicle length in % of thoracic length	38	36	32	30	33	32

* Due to fractures the number of individuals in some categories is one or two less than that listed for the group as a whole.

venience on the front of the body. The distance from suprasternale to symphysion depends on: (1) the length of the thorax, (2) the length of the lumbar region, and (3) the distance that symphysion lies caudal to the sacral promontory.

Table 1 gives the lengths of the thoracic and lumbar regions, calculated from the percentages given by Schultz (1938), and an approximate measure of the pelvic part of trunk height. This last was obtained by subtracting the lengths of the thoracic and lumbar regions from trunk height and is based on the assumption that suprasternale lies opposite the first thoracic vertebra and that the curve of the vertebral column does not introduce too large an error. (Comparison with the promontorium-symphysion distance, measured on the skeleton, shows these figures to be slightly low, as would be expected from the sources of error listed above).

In all the females, even in the small macaques, the pelvic part of trunk height is absolutely larger than in the males, just as is the promontorium-symphysion distance measured on the skeleton. Also it will be noted that the lumbar regions of the females are longer (relative to weight, thoracic region, or male lumbar region) than would be expected. Since the lumbar regions of infants are shorter than the thoracic regions (Schultz, 1938, Table 6), the long female lumbar region is regarded as a specialization.

The trunk heights of the females are relatively longer than those of males because the lumbar region and the promontorium-symphysion distance are longer.

Relative to size there is little sex difference in the thoracic region of these monkeys. Therefore the thoracic region will be used in subsequent comparisons where a standard with a minimum of sex difference is desired. The validity of this procedure will be demonstrated as this study progresses, because sex differences, which appear when trunk height is used as the comparative standard, disappear when other standards are substituted, showing the presence of a sex difference in trunk height itself.

Sternum

The macaques average more sternaebrae than the langurs. Keith (1921), Schultz (1930), Wood Jones (1929), all state that 5 or 6 sternaebrae are typical of monkeys. Sonntag (1924) says 6 to 8 sternaebrae (presumably counting the xiphoid process) are typical of

monkeys. (He gives no data on species, sex, or number of cases). Here it is shown that 7 sternaebrae are frequent in the macaques, that 5 is the mode in the langurs, and that the number varies even in the same species and sex from the same locality.

Cases of union of sternal elements have never been reported from monkeys. It was encountered here in none of the macaques. There was one case of union between the 4th and 5th sternaebrae in crested males and one in the females. (In such cases the number of sternaebrae was counted as if no union had occurred). In maroon males, 6 of 19 cases show various degrees of union. In all these the joints between the third and fourth and fourth and fifth sternaebrae are partially or wholly obliterated. In one case the first joint is completely closed, in one other the second. These sterna are from adult animals. However, some are young adults. It appears that normally in old maroon males the third and fourth sternal joints are obliterated.

Cases of union are rarer in the maroon females, occurring in the 3rd sternal joint in two cases and the 4th in one.

In the crested langurs, one case of mid-sagittal division of the fourth and fifth sternaebrae was observed, and two cases of division of the fourth and fifth with traces of division on the third. This type of division, seen in man, orang-utan, and gibbon (Schultz, 1930), has not been reported in monkeys before.

The sterna of macaques are relatively longer than those of langurs and sterna of the females are shorter than those of males. These differences may best be expressed by relating the length of the sternum to that of the thoracic region. This index clearly shows the group and sex differences. It should be noted that sex differences are larger than some of the group differences. This illustrates the need for keeping males and females separate in comparative studies or the composition of the samples will affect the results.

The manubria of the langurs are, relative to corpus length, much longer than those of the macaques. The crested male mean (43) overlaps that of the chimpanzee (42.7), according to Schultz (1930), and individuals surpass the human mean (46.2, according to the same author). Thus this index can no longer be regarded as separating the higher catarrhines from the monkeys.

The corpus length-breadth index is much higher in the langurs than in the macaques, principally due to the greater width of the corpus in the langurs. Four of the maroon males exceed the mean of 21.4

percent given for the chimpanzee by Schultz (1930), so that this index also may no longer be regarded as separating the higher and lower catarrhines.

In summary, it may be said that tendencies to broaden and shorten the sternum are present in some monkeys, as are also reduction in the number of sternaebrae, union of sternaebrae, and mid-sagittal division. Clearly, in so far as these points are concerned, the differences between higher and lower catarrhines are much less than have been previously supposed.

Each group of monkeys presents different characteristics. In evolutionary studies it makes a great deal of difference which monkey is compared to the higher catarrhines.

Clavicle

The only index in general use to describe the size of the clavicle is the clavicle-humeral index. According to this, there is no clear difference between these macaques and langurs. Relative to thoracic length, the macaques have longer clavicles than the langurs. According to both indices the maroon langurs have longer clavicles than the crested langurs. Sex differences are present in all three groups and by both methods, so that there is no doubt that the females have shorter clavicles.

Comparative data are limited to the claviculo-humeral index. Schultz's (1937) data on rhesus macaques are very similar to the present data on macaques (♂ 39.5, ♀ 36.7).

Little can be done with the claviculo-humeral index alone because similar indices may be found in gibbons and macaques, obviously arising under radically different circumstances. The actual measurements and the claviculo-thoracic index help to determine which element has varied.

Scapula

The macaques' scapulae are longer and narrower than the langurs' (Table 2). The morphological length of the male macaques exceeds even the crested langur males, although the latter weigh 1.9 kilograms more, have a trunk height 63 mm. longer, and a humerus 17 mm. longer. Even the female macaques equal or exceed the female langurs in scapular length, although much smaller in weight, trunk height,

TABLE 2

Mean and ranges of variations (in parentheses) of scapula and pelvis discussed in this study

CHARACTER	MACACA IRUS		TRACHYPITHECUS PYRRHUS CRISTATUS		PRESBYTIS RUBICUNDA	
Measurements (mm.) and proportions	*15 males*	*11 females*	*12 males*	*22 females*	*19 males*	*17 females*
Scapula: Length	63(57-70)	52(48-56)	58(55-63)	52(47-56)	52(49-54)	49(47-52)
Breadth	55(47-63)	44(38-49)	63(57-68)	55(52-58)	59(48-64)	57(53-60)
Length in % of breadth	117(108-128)	118(108-126)	93(86-100)	94(84-102)	88(81-104)	87(83-98)
Supraspinous fossa breadth	15(12-18)	12(10-14)	16(14-18)	14(12-15)	10(8-11)	10(8-11)
Infraspinous fossa breadth	39(34-45)	31(27-35)	47(42-50)	41(39-45)	49(40-54)	47(44-49)
Upper fossa in % of lower fossa	38(33-44)	39(33-44)	34(30-38)	33(28-37)	20(16-22)	21(17-22)
Axillary border length	69(60-77)	58(51-65)	72(70-77)	66(62-69)	69(64-74)	68(62-74)
Spine length	72(64-81)	60(56-63)	67(63-71)	59(55-63)	60(58-62)	57(55-60)
Pelvis: Ilium length	80(70-88)	71(63-76)	82(77-88)	83(78-88)	77(72-80)	80(75-84)
Ischium length	38(36-41)	31(29-34)	38(36-41)	35(32-37)	41(38-45)	40(38-42)
Pubis length	32(29-38)	33(30-37)	31(28-33)	36(32-39)	28(27-30)	36(33-40)
Ilium breadth	29(25-32)	25(22-28)	35(30-40)	35(31-40)	37(30-40)	36(32-40)
Ilium breadth in % of ilium length	36(30-40)	35(30-40)	43(38-48)	42(39-48)	48(41-52)	45(40-50)
Ilium length in % of ischium length	210(193-232)	229(210-241)	216(200-230)	237(217-252)	188(175-211)	200(186-215)
Pubis length in % of ischium length	84(80-93)	105(97-116)	80(75-85)	102(91-109)	68(62-74)	91(83-100)
Promontorium-symphysion distance	56(47-66)	60(55-66)	54(48-57)	63(59-66)	45(42-51)	55(46-64)
Pelvic inlet breadth	40(34-46)	41(36-46)	42(38-44)	45(42-48)	40(38-44)	48(44-53)
Pelvic inlet length in % of breadth	140(118-165)	146(130-164)	129(109-141)	140(130-149)	112(102-124)	115(104-128)
Synostosis of pubic symphysis, cases	1	None	1	None	16	6

and humerus length. The difference in the scapular length-breadth index depends mainly on this great length of the macaque's scapula. Therefore the langurs' scapulae are better described as short than broad.

The spinal fossae index is higher in the macaques, but there is considerable individual overlapping, while in the scapular index there is no langur in the range of variation of the macaques. The maroon langurs are the most aberrant in regard to this index because they have the narrowest supraspinous fossa associated with the widest infraspinous fossa.

The infraspinous fossa divided by the morphological length gives an index of the means of 95 percent in both male and female maroon langurs. In the males there is one case of an index of 101 percent, and in the females one case of 102 percent. Indices of over 100 percent have only been reported as occurring in man and orang-utan (Schultz, 1930).

The great length of the axillary border relative to other scapular dimensions serves to separate the langurs from the macaques. In all the langurs the axillary border exceeds spine length, the next greatest dimension, and is less than spine length in the macaques.

Variability in the scapular indices is very marked. The range of the scapular index is 24 in maroon males. Martin (1928) gives the range for this index in the Cercopithecidae as 110 to 144. The maroon langurs extend this range by thirty units, or 86 percent.

As was the case with the sternum, these data show that numerous conditions thought to be unique in the higher catarrhines are actually present among the lower.

Pelvis

The male macaques have a relatively larger pelvis than either of the langurs (Table 2). Compared to the much larger crested langur males, the male macaques have ilia shorter by only 2 mm., ischia equally long, and longer pubes. Compared to the maroon langurs, the macaques are longer, except in length of ischium.

The ilium-length-breadth index, although it is the best sorting device in this material, does overlap, and overlaps extensively between the Cercopithecinae and the Semnopithecinae in other forms (Straus, 1929). Values for the baboon are particularly high (Straus, 1929; Schultz, 1930). The pronounced differences in the present material

seem to be due to the narrowness of the ilium in the macaques. The high index of the maroon langurs is conditioned by their ilia being both short and broad.

The maroon langurs appear to differ more from the crested langurs than the latter differ from the macaques in the ilium-ischium and pubis-ischium indices. The maroon langurs have longer ischia than the crested, although the crested langurs are larger in all other measurements, except ilium breadth. To test whether the ischiatic length is the variable, it was divided by thoracic length. This gives an index of 29 for both male and female macaques; 27 for male maroon langurs, and 26 for females; 24 for crested males, and 23 for females. The ischium should be considered with the lower extremity, rather than with the pubis and ilium. A comparison between the length of the femur and that of the ischium shows the following: macaque male, 27, and female, 25; crested male, 21, and female, 20; maroon male, 20, female, 20. It is apparent that the long ischium of the maroon langurs is correlated with their long femur, and that the apparent great difference in the pelvic proportions between the langurs is caused by the retention of the same femur-ischium relations.

Sex differences in the pelvis are large. Relative to the ischium, which shows little sex difference, females have longer ilia and pubes. Study of the means shows that even in the small female macaque the pubic bone is absolutely longer than that of the male. The ilium-ischium index may overlap considerably in the two sexes, but the ischium-pubis index does not overlap in any of the three groups.

The promontorium-symphysion distance is always, even in the small macaques, absolutely longer in the female than in the male. This measurement is partially dependent on what Straus (1929) called "lower iliac height", that is, the distance from the "point of ilio-pubic junction on the pubic border (iliopectineal line) to the point where this border or its extension meets the articular surface." Straus has shown that this lower iliac height is longer in females.

The female macaque is remarkable because its promontorium-symphysion distance is absolutely longer than that of the much larger maroon langur. In other words, an animal with a thoracic length of 108 mm. has a greater promontorium-symphysion length than one with a thoracic length of 151 mm. The maroon females would require a promontorium-symphysion length of 77 mm. in order to have an equivalent thorax-promontorium-symphysion relationship. This meas-

urement accounts for much of the sex difference in the pelvic part of the trunk height, as previously noted.

Inlet breadth (Martin, 1928) is wider in the maroon than in the crested langurs. The pelvic index (Martin, Beckeneingang index) is higher in the female than in the male. Since the breadth is increased over that of the male, this means that the length is increased even more. The macaques have the highest index and the maroon langurs the lowest. Sex differences in size are more marked than index differences. The ranges of the pelvic inlet indices overlap extensively.

Howells and Hotelling (1936) note that in the pelvis of Indians of the Southwest "sexual differences are no less pronounced than in Europeans, contrary to the notion that such distinctions are ill-defined in extra-European peoples." Here it is shown that sex differences are clearly defined in monkey pelves—so clearly, in fact, that there is no overlap in some characters.

These pelvic indices are subject to considerable variation. The range of the ischium-pubis index of the macaques (male and female combined) would include in its range every ischium-pubis index given in Table 17 of Schultz (1930), (Schultz's data; range, 80.7 to 111.8; range of macaque, 80 to 116), except one infant chimpanzee. The ischium-ilium index in the present material ranges from 175 to 252 and would include all the primates listed in the above-mentioned table except *Oedipomidas* and man. Clearly, with indices which vary so much and show such large sex differences, valid group differences can be established only with moderately long series, and with the sexes always kept separate. It is also clear that what differences are found in these indices in a comparison of higher and lower catarrhines will depend on which monkey is used as a basis for comparison.

There are several points which have not been investigated fully, but are obviously so different from present descriptions that they are worth noting. Weidenreich (1913) gives the angle made by the axis of the ilium with the axis of the ischium as varying from 150° to 160° in catarrhines and anthropoids. He states that he has limited material and that these angles might be subject to small corrections. In the macaque males this angle may be more than 155°, and in maroon males it may be less than 135°. Doubling the estimated range is certainly more than a small correction.

The pubic symphysis of the langurs is long and may even be ossified. Todd (1921) described one maroon langur which he noted

had accelerated changes at the symphysis. These data show that such acceleration is normal in this species and that age changes in the pubic symphysis of Old World monkeys are not uniform, as Todd apparently supposed.

It is interesting to note that in the maroon females the caudal end of the sacrum lies at about the same level as the pubic symphysis (comparison introduced by Schultz, 1936) and in the males below that level. This relationship is due to the short lower iliac height already discussed. In the macaque the caudal end of the sacrum is anterior, as pointed out by Schultz.

The intermembral index (humerus + radius in percent of femur + tibia)

The intermembral index clearly differentiates these three groups of monkeys (Table 3). The macaques have high indices (90-95) because, relative to trunk height, the humerus and radius are long and the femur and tibia short. The crested langurs have intermediate indices (80-84) because humerus and radius are slightly shorter and femur and tibia slightly longer than those of the macaques. The maroon langurs have the lowest indices (74-78) because the lower extremity is so long that the index is low, despite a long upper extremity.

The sex differences in the limb-length trunk-height ratios are probably due entirely to the sex difference in trunk-height and not to differences in the limbs themselves.

The intermembral index of macaques is a little higher than that which Mollison (1910) obtained on six irus macaques, and also higher than Schultz's values for rhesus macaques (male, 87.4 and female, 87.6; 1937). The mean intermembral index of the maroon langur is lower than any recorded by Mollison in his Old World monkeys. His two entellus monkeys had indices of 78 and 79; his two guerezas, indices of 77 and 79.

Brachial index (radius length in percent of humerus length)

The humerus and radius of the macaques are nearly the same length, the radius of the crested langurs is shorter than the humerus, and the radius of the maroon langurs is longer than the humerus. These relations are exactly stated by the brachial index. The macaque and crested langur ranges overlap extensively, but maroon langurs

TABLE 3

Means and ranges of variations in (in parentheses) of the limbs discussed in this study

CHARACTER *Measurements (mm.) and proportions*	MACACA IRUS		TRACHYPITHECUS PYRRHUS CRISTATUS		PRESBYTIS RUBICUNDA	
	15 males	*11 females*	*12 males*	*22 females*	*19 males*	*17 females*
Limbs: Intermembral index	91(90-95)	92(90-94)	82(80-83)	82(80-84)	75(74-77)	76(75-78)
Humerus length	126(116-137)	111(104-120)	143(133-150)	138(131-142)	135(129-140)	133(126-139)
Radius length	124(111-133)	107(103-112)	135(124-140)	129(124-136)	155(145-161)	151(145-156)
Femur length	143(132-157)	124(116-133)	180(166-192)	173(164-180)	202(194-208)	195(187-202)
Tibia length	130(117-142)	114(108-123)	161(153-168)	154(145-164)	184(172-194)	176(169-182)
Humerus + radius in % of trunk height	82(78-87)	81(77-85)	76(73-79)	75(70-82)	83(80-89)	82(75-85)
Femur + tibia in % of trunk height	90(86-96)	88(82-93)	93(90-97)	91(85-99)	111(105-118)	107(100-111)
Radius length in % of humerus length	98(94-101)	97(92-100)	94(93-97)	94(91-98)	115(109-119)	113(108-118)
Tibia length in % of femur length	91(89-93)	92(90-94)	90(86-92)	89(87-92)	91(88-94)	90(89-92)
Digital formulae, hand and foot	Long medial digits		Long lateral digits		Long lateral digits	
Cases of union of os centrale to scaphoid	None	None	None	2	None	None
Foot length	132(115-142)	115(108-122)	161(149-167)	154(142-165)	176(160-185)	169(160-176)
Foot length in % of trunk height	43	42	44	43	50	48
Foot length in % of femur + tibia length	48	48	47	47	46	46

are clearly separated from the others. In both langurs the humerus has about the same length relative to trunk height, thus the difference in the brachial index is due almost entirely to differences in radius length.

Mollison (1910) has shown that baboons may have high brachial indices (up to 116 on the skeleton); thus indices range from the low nineties or even high eighties (87 in one *Cercopithecus,* Mollison) in both the Cercopithecinae and Semnopithecinae.

Crural index (tibia length in percent of femur length)

The crural index is very constant in this material. The total range, including both sexes and all three groups, is from 86 to 94. Perhaps the langurs have slightly lower indices than the macaques. Their ranges start lower, and 89.5 was the lowest crural index recorded by Schultz (1937) on 79 rhesus monkeys. However, the differences, if any, are small and could only be proved by statistical justification on longer series.

Hands and feet

The langurs differ from the macaques in having relatively longer lateral digits and particularly longer lateral metacarpals and metatarsals. Clark (1934) and Wood Jones (1929) state that $3 > 4 > 2 > 5 > 1$ is the typical digital formula of all Old World monkeys. It is characteristic of both hand and foot in all the macaques and of all but three of the hands of the maroon langurs. One half of the crested langurs have longer lateral digits on the hands, $3 = 4 > 5 > 2 > 1$ being the most divergent formula observed (2 cases). In the feet only 1 crested and 6 maroon langurs have the "typical formula", $3 = 4 > 5 > 2 > 1$ being the most extreme formula observed (2 cases in maroon and 2 in crested langurs). The great length of the fifth digit relative to the second in the langurs is the easiest way to distinguish these hands and feet.

The lengthening of the lateral digits is also typical of some *Colobus* monkeys (Midlo, 1934). This makes the digital formula approach that of certain lemurs. Midlo describes one of six *Colobus* monkeys as having a digital formula of $4 > 3 > 5 > 2 > 1$. This is slightly more extreme than any of these langurs and shows that monkeys can not be distinguished from lemurs on the basis of the digital formula alone.

The os centrale was united with the scaphoid in 2 female crested langurs. Both occurrences were bilateral. This has never been described in a lower catarrhine before.

The length of the foot was measured with a tape from heel to tip of third toe. Relative to trunk height, the macaques have the shortest feet and the maroon langurs the longest. In each of the three groups the females have shorter feet than the males. Relative to the rest of the lower extremity (femur and tibia), the macaques have the longest feet, the maroon langurs have the shortest, and there is no sex difference. The second proportion shows that the sex difference in the trunk height-foot ratio is due to the sex difference in trunk height.

Skull

Cranial capacity

Since Schultz has recently (1941) published a comprehensive study of the relation of cranial capacity to body size in primates and reviewed the literature on this subject, it is only necessary to show how these data supplement those collected by Schultz. The female rhesus macaques (10 adult females, mean weight 5,861 gms.) described by Schultz have a capacity-weight (capacity in cc. in percent of weight in gms.) index of 1.55, compared to 1.03 and 1.10 in the crested and maroon langur females. To give the maroon females an equivalent index, the capacity would have to be increased to 93 cc., a value far beyond the actual range of variation (only 60-70 cc.). The change would be even greater in the case of crested females as their capacity would have to be increased to nearly 90 cc. (actual range, 54-65 cc.).

Our data (Table 4) show that there is a large difference between langurs and macaques of equivalent weight. The difference is approximately as large as that which separates the rhesus macaques from the lar gibbons.

Comparing adult animals of almost exactly equal weight and of the same sex, as we have done here, eliminates many of the difficulties which attend comparing animals of different size and sex. By exact pairing (same sex and weight) direct comparisons can be made, and this greatly simplifies the interpretation of results.

TABLE 4

TABLE 4

Means and ranges of variations (in parentheses) of the skulls discussed in this study

CHARACTER *Measurements (mm.) and proportions*	MACACA IRUS		TRACHYPITHECUS PYRRHUS CRISTATUS		PRESBYTIS RUBICUNDA	
	16 males	*12 females*	*12 males*	*22 females*	*19 males*	*17 females*
Skull: Cranial capacity in cc.	65(56-72)	57(50-62)	64(57-71)	60(54-65)	74(66-83)	66(60-70)
Capacity (cc.) in % of body weight (g.)	1.35	1.90	.96	1.03	1.19	1.10
Skull length (glabello-occipital)	76(72-80)	71(69-73)	76(72-81)	71(68-74)	74(72-77)	73(71-76)
Braincase breadth	55(53-59)	52(49-54)	54(51-56)	53(51-56)	56(54-58)	54(51-56)
Braincase breadth in % of skull length	72(69-77)	73(69-77)	71(68-74)	75(70-79)	75(70-77)	74(71-78)
Basion-vertex height	48(45-52)	45(42-47)	46(45-48)	45(43-47)	50(47-51)	48(47-50)
Base length (basion-nasion)	59(56-64)	52(49-55)	59(55-62)	55(53-56)	57(54-64)	57(55-60)
Palate length	52(45-56)	42(38-44)	39(36-41)	35(34-36)	33(31-35)	32(31-33)
Palate length in % of base length	87(80-92)	80(76-83)	66(63-68)	63(61-65)	58(54-61)	56(55-58)
Face height (nasion-prosthion)	53(42-48)	43(41-47)	33(31-36)	30(27-33)	31(28-33)	30(28-33)
Basion-prosthion	84(74-90)	67(61-72)	69(64-73)	63(60-65)	60(58-63)	59(58-62)
Basion-prosthion in % of base length	142(132-147)	129(124-136)	118(115-120)	115(111-119)	105(101-109)	104(103-106)
Palate breadth	36(33-38)	33(31-34)	33(32-35)	32(30-34)	31(30-32)	30(29-32)
Palate breadth in % of palate length	69(63-76)	78(74-82)	86(82-89)	92(86-97)	94(91-100)	94(91-97)
Postorbital breadth	40(37-45)	38(35-40)	41(40-42)	41(38-42)	46(43-47)	45(43-46)
Postorbital breadth in % of braincase b.	73	73	76	77	82	83
Biorbital breadth	61(55-67)	52(50-55)	63(58-67)	58(56-62)	62(59-63)	61(58-63)
Orbital breadth	21.4(20-23)	20.5(20-21)	22.1(21-23)	21.8(21-23)	23.5(22-24)	23.9(23-24)
Orbital height	20.8(19-23)	20.8(19-22)	22.3(21-23)	22.5(20-25)	22.8(21-24)	23.5(23-24)
Orbital height in % of orbital breadth	97(83-109)	101(90-110)	101(91-110)	103(91-110)	97(92-104)	98(96-100)
Interorbital breadth	5.2(4-6)	3.9(3-5)	9.4(8-11)	8.6(7-10)	7.9(7-9)	7.9(6-9)
Nasal bones, length	28(18-36)	20(13-25)	10(8-13)	9(6-12)	10(8-12)	11(7-14)
Nasal opening, height	17(15-19)	14(12-16)	16(15-17)	15(14-16)	14(13-16)	13(12-15)
Inter-nasal suture	Closes early		Closes later		Closes latest	
Maxillary sinus	Present		Absent		Absent	

Cranial measurements

Comparison of cranial length, breadth and height, or their averages, shows even smaller differences than did cranial capacity. This is because the monkeys with the smaller capacities have thicker skulls.

Length-breadth index

Although there are small differences in the mean values of this index, these are not significant because of the nearly complete overlapping of the ranges. In both the macaques and crested langurs the index is lower in the males than in the females. In both cases this is due to the fact that the male's head is longer, because of thicker glabella and inion regions.

It will be noted that all these monkeys fall in the long- or medium-headed category. The range for all the material is from 68 to 79. This conclusion differs from that of Oppenheim (1911), quoted by Martin (1928), who found all groups of Old World monkeys round-headed. This difference is due to the fact that Oppenheim calculated the length-breadth index with a length measured from supraglabellare. Monkeys are not round-headed if the head length is measured from the glabella.

Martin (1928) suggests that the variability in some of Oppenheim's groups may be due in part to the lack of separation of varieties of monkeys. In our material the range of one sex from one locality is greater than that of Oppenheim's *Cynomolgus* or *Semnopithecus*.

Basal length (basion-nasion)

To standardize this measurement, nasion is considered to be at the level of the fronto-maxillary suture, or its continuation, in the mid-sagittal plane. In the macaques the true nasion may be as much as a centimeter below this point. Nasion and this mid-fronto-maxillary point approximately coincide in the langurs. In this measurement the male macaques equal the crested langurs (base length, 59) and surpass the maroon langurs (base length, 57). This emphasizes the great size of the macaques' skull.

Facial size

The macaques have larger facial skeletons than the langurs and particularly larger palates associated with much larger teeth and muscles

of mastication. Even the small, 3-kilogram female macaques surpass the 6.7-kilogram male crested langurs in palate length. No other langur is in the range of variation of the female macaques, although all are larger animals. Comparisons are facilitated by expressing palate length in percent of base length. The lowest index of a female macaque (76) is much higher than the highest index of any male langur (68).

Largely because of this great palate length, these macaques have longer faces and are more prognathous than the langurs. Prognathism in this material is best described by comparing the base length to the basion-prosthion distance. In the maroon langurs the basion-prosthion distance may barely exceed the base length (index 101), while in the macaques the index may rise to 147. All three groups of monkeys are separated by this index with no overlapping.

Palate length-breadth index

Two crested adult males with the narrowest palates have the same index as the macaque female with the relatively broadest palate (index, 82). Since the macaques have absolutely as wide or wider palates than the langurs, this index serves to stress the great difference in palate length.

As the palate increases in size, length increases more than width in both langurs and macaques. If the material is arranged in order of ascending palate length, it is also arranged in order of ascending palate width and descending palatal index.

		Palate length	*Palate breadth*	*Palate index*
Maroon langur:	female	32	30	94
	male	33	31	94
Crested langur:	female	35	32	92
	male	39	33	86
Macaque:	female	42	33	78
	male	52	36	69

Important from a taxonomic standpoint is the difference in the index if the widths are equal (crested male and macaque female). Also important are the conditions under which equality can be found (here only by comparing a female to a male of over twice the weight).

Postorbital breadth

Correlated with their large faces, the macaques have the greatest postorbital constriction. This constriction is less in the crested and least in the maroon langurs.

Biorbital breadth

Biorbital breadth is a composite dimension, and the factors on which it depends are shown in the following table.

		Biorbital breadth	*Twice orbital breadth*	*Interorbital breadth*	*Malar breadth*
Macaque:	male	61	42.8	5.2	13
	female	52	41	3.9	7.1
Crested langur:	male	63	44.2	9.4	9.4
	female	58	43.6	8.6	5.8
Maroon langur:	male	62	47	7.9	7.1
	female	61	47.8	7.9	5.3

The table is based upon the following: twice the orbital breadth plus interorbital breadth is subtracted from biorbital breadth. The difference represents the part of biorbital breadth composed by the frontal process of the malar bone. Checking on the specimens shows that the figures are approximately correct, except that the malar breadth of the crested female is probably too low.

The table shows that all the three components of biorbital breadth are different in the three groups of monkeys. A direct comparison of the macaque males with the maroon females, shows that the biorbital breadth is the same but that every component is different.

Differences in malar breadth and interorbital breadth (associated with larger jaws) accounts for most of the sex difference in biorbital breadth.

This type of analysis shows the difficulties of interpreting comparisons of all primates on the basis of the frontobiorbital index (see Oppenheim, 1911). To the author, it seems little more than chance that Oppenheim's *Semnopithecus* (two species, both sexes) happens to have nearly the same index as *Symphalangus* (71 and 72). Disregarding the differences in the components of biorbital breadth, whether the index is like that of *Symphalangus* or not, depends on

which langur is chosen. Even sex differences in this index are larger than Oppenheim's group differences, and Oppenheim's groups of lower catarrhines, except *Cynocephalus,* are of both sexes. These same difficulties will appear if an interorbital index (interorbital breadth in percent of biorbital breadth) is used.

Orbital measurements

In contrast to the majority of facial measurements, the macaque males have slightly smaller orbital dimensions than the langurs. This emphasizes that the difference in facial size is primarily due to the dental difference.

In each group the female has a higher orbital index than the male, probably due to greater brow-ridge development in the male (as suggested by Martin, 1928). This is confirmed by observation and the degree of difference in the index (which is greatest in the macaque and least in the maroon langurs).

Interorbital breadth (the minimum breadth that can be taken with sliding calipers, Weinert, 1927)

The langurs have wider interorbital breadths than the macaques. This finding agrees with that of Weinert (1927).

The sex differences in interorbital breadth appear to depend on the greater size of the frontal process of the maxilla in the males. This is clearly associated with a greater development of the whole facial skeleton.

Nasal measurements

The nasal bones of the macaques are approximately twice as long as those of the langurs. This difference is, probably, correlated with the difference in upper facial height.

The variation in the length is great in all groups. It is much greater than the variation in the height of the nasal opening (measured from the tip of the nasal bones to the lowest point on the border of the opening in the mid-sagittal plane). This shows that the nasion is extremely variable in these monkeys.

Internasal suture

Oppenheim (1911) has called attention to the late closure of the internasal suture in *Semnopithecus.* Bolk (1912) came to the same

conclusion. In the rhesus macaque Schultz (1937) has shown that the internasal suture is already closed at birth. The same is probably true of these macaques, since the suture is closed in all five infants available for examination.

The following table shows the conditions in the adult langurs.

		Open	*½ to ¾ closed*	*Closed*
Crested langur:	male	0	0	12
	female	4	4	14
Maroon langur:	male	6	4	9
	female	9	7	1

Of two sub-adult crested males, one had the internasal suture one-half open and the other completely open. This suture was open in all of four juvenile males, so it appears that closure takes place at about the time of complete eruption of the third molars. In crested females the internasal suture closes a little later. It was completely open in three sub-adults, and even in four adults. Bolk (1912) reported the same sex difference in *Semnopithecus*. In maroon males this suture is open, or partially open, in half the adults. In the females it is closed in only one of seventeen cases.

In some monkeys the internasal suture closes later than in most of the higher catarrhines. Perhaps the most important aspect of these data is the variability shown by the different groups of monkeys.

DISCUSSION

The greatest proportional difference between these langurs and macaques is in the tooth-bearing part of the facial skeleton. The langurs are specialized leaf eaters, having crested molar teeth (Gregory, 1922) and enormous sacculated stomachs (Weber, 1928). The proportional differences in the face are best considered as correlated with these fundamental herbivorous specializations.

According to Gregory (*op. cit.*), the most primitive fossil genera of the Semnopithecinae (*Dolichopithecus, Mesopithecus*) had large muzzles. Therefore, the short-faced langurs described in this paper must be considered specialized modern forms, whose evolution has in some feature paralleled the short-faced gibbons but for entirely different reasons.

The precise difference in facial size between langurs and macaques cannot be stated at the present time because of the lack of comparative data and because of the variability in the groups being compared. Oppenheim's paper (1911) would seem to be the best source of comparative material. However, Oppenheim considered the skulls only. Since the greatest difference between these langurs and macaques is in facial size relative to body size, it is clear that Oppenheim's study fails to furnish the data needed. If the skulls of langurs and macaques are compared without reference to body size, the skulls of small macaques are comparable to those of much larger langurs. For example, the female macaques are quite similar in the majority of their cranial dimensions to the male crested langurs, but the male crested langurs weigh more than twice as much as the female macaques. They are much larger animals. Since large animals tend to have relatively larger faces than small ones of the same stock, comparing larger langurs to small macaques minimizes the difference in the facial skeleton. This explains why a study of the skull alone will not reveal some of the greatest differences between langurs and macaques.

Another difficulty with the use of Oppenheim's data is that the groups of lower catarrhines (except baboons) are composed of animals of both sexes. As pointed out earlier, sex differences within a species are often larger than the differences Oppenheim found between groups of monkeys. If comparisons are limited to animals of the same sex, differences will appear significant which do not appear so in mixed samples. For example, if the macaque males are compared only to the langur males, facial differences constantly appear larger than when the macaque females are used for comparison with the langur males.

If samples composed of both sexes are used, the proportion of the males and females in the sample, and the degree of sex differences in the group under comparison will affect the results. The indiscriminate averaging of monkeys of both sexes was done probably on the assumption that sex differences are poorly defined in monkeys. It has been shown that sex differences are well defined in these monkeys, so such a procedure can no longer be considered justified.

Until more data on other groups of Semnopithecinae are available, it can not be determined just how rare some of the conditions described in this paper actually are. At least it is clear that many characters which have been described as occurring only in the higher catarrhines are present in the lower also. In this connection might be mentioned

particularly: fusion and mid-sagittal division of sternaebrae, wide corpus sterni, union of os centrale to scaphoid, and many proportions to which attention has previously been called.

If these monkeys were similar, then they might be treated as samples typical of many other groups of macaques and langurs. However, the inter-group differences are large and even the intra-group variability in many proportions is so great that average indices without regard to variability mean little. The following list gives the ranges of some of the indices in this material (total range of the macaques, crested and maroon langurs): brachial index, 91-119; intermembral index, 74-95; manubrium length in percent of corpus length, 26-55; scapular length-breadth index, 81-128; spinal fossae index, 16-44; ilium length in percent of ischium length, 175-252; ilium length-breadth index, 30-52; index of prognathism, 101-147; palate length-breadth index, 63-100; orbital index, 83-110. These ranges would undoubtedly be further extended if more series of monkeys were available. (A *Cercopithecus* monkey described by Mollison had a brachial index of 87; a baboon, an intermembral index of 99. Schultz described a baboon with a scapular index of 142.7. Oppenheim described a baboon with an orbital index of 68).

Because of this variability it makes a great deal of difference which type of monkey is used in comparisons of the lower to the higher catarrhines. This is clearly illustrated by substituting the proportions of the male maroon langurs for the "lower catarrhines" used by Schultz (1933) in his comparison of gibbons and lower catarrhines.

	*Lower catarrhines**	*Hylobates**	*Brachytanytes**	*Maroon langurs Male***
Brachial index (radius in % of humerus length).....	*ca.* 100	112.4	116.5	115 (109-119)
Crural index (tibia in % of femur length).....	*ca.* 91	88.2	89.7	91 (88-94)
Intermembral index (humerus + radius in % of tibia + femur).....	*ca.* 89	128.5	126.5	75 (74-77)

* From Schultz, 1933a.
** Author's data.

According to Schultz's table, there is a large difference between the lower catarrhines and the gibbons (*Hylobates* and *Brachytanytes*) in the brachial index, a very small difference in the crural index, and an extremely large difference in the intermembral index. If the gibbons are compared to the maroon langurs it is seen that the gibbons' brachial

and crural indices would not be unusual for the langurs. But the difference in the intermembral index is even greater than in Schultz's table.

Comparisons with other groups of Old World monkeys show that high and low brachial indices appear in both Cercopithecinae and Semnopithecinae. This index not only fails to separate the higher and lower catarrhines but does not even distinguish the two subfamilies of Old World monkeys. Further comparisons of the crural index give similar results. Differences between higher and lower catarrhines, or even between groups of monkeys, would be in mean indices only with extensive overlapping in the ranges. The crural index differs far less from group to group than the brachial, and the similarity of range in gibbons and monkeys is more significant than any small difference in the means.

Additional comparisons of the intermembral index show that, although it varies considerably (74-95), the indices of the gibbons remain far beyond the range of variation of any monkeys.

From the foregoing it is clear that there is no great difference between monkeys and gibbons in the brachial or crural indices but that there is a great difference in the intermembral index because the intermembral index of the gibbons is beyond the range of variation of the monkeys. The use of ranges of measurements and indices permits the determination of which are most different, which separate the groups being compared without overlapping. Attention may then be concentrated on the understanding of these greatest differences.

Direct comparison of the long bones of monkeys and gibbons of approximately equal weight shows that the high intermembral index of the gibbons is due primarily to long upper extremities. Since, according to Mollison and Schultz, the gibbons have long lower extremities, their high intermembral index is due to the fact that the upper extremities are so long that the index is high in spite of the long lower extremities. The difference in length of the upper extremity is even greater than would be expected from the intermembral index alone.

In comparison of lower catarrhines and gibbons, the use of ranges makes it possible to show which of the three proportions separates the lower catarrhines and gibbons with no overlapping. The analysis of the index showing the greatest difference permits the determination of the measurement on which the index difference is primarily dependent (in this case, the length of the upper extremity). Use of

the range simplifies comparisons by concentrating attention on the greatest differences. Analysis of the indicial differences simplifies comparisons by showing which measurement is primarily responsible for the difference in the index.

The necessity for an objective method of determining where the greatest differences lie and for concentrating attention on them is shown by examination of the number of measurements which Oppenheim used in her study of the primate skull (1911). Oppenheim describes 124 measurements, angles, and indices used in the description of the skull alone, and this number she subsequently increased (1930). The result is a bewildering number of differences and similarities. Some system is needed to give emphasis so that the most significant differences can be discovered. Future studies may then be simplified.

For example, in the light of the data presented in this paper and that of Mollison, Oppenheim, and Schultz, a future study on langur and macaque differences might concentrate on those characters and proportions shown to be most different in this study (size of skull relative to body, proportions of scapula, sternum, and digits).

Likewise a comparison of the higher and lower catarrhines might concentrate on those differences beyond the range of individual variation (especially, length of upper extremity including the clavicle, length of the acromion process of the scapula, length of lumbar region). In addition several characters not treated in this paper, such as the shape of the thorax and great toe, might be added.

This is not to suggest that studies ought to be limited to these few features. Studies on additional series of monkeys will undoubtedly modify these conclusions. Also proportions common in one group and rare in another (such as some sternal proportions in higher and lower catarrhines) are well worth recording. Such features may prove to be examples of convergent evolution (as the writer regards the width of the corpus sterni in maroon langurs), showing fundamental similarity in the catarrhines, rather than specific likeness between one group of langurs and the higher catarrhines.

However, the knowledge that the brachial index varies greatly between species of monkeys, that the crural index varies little in all the catarrhines, and that the length of the upper extremity separates all higher and lower catarrhines, permits these proportions to be viewed with proper perspective. A proportion which varies greatly from species to species cannot be expected to have been modified uniformly

in one direction during evolution. The numerical value found for such a proportion will depend almost entirely on which group of monkeys is being studied, or if a mean is used, it will depend on the weighting of various groups in the sample.

When more series of monkeys are available, it will be possible to show which characteristics are specific, generic, or familial, and why, in terms of the actual measurements, these differences exist.

The importance of this last step, the analysis of the index, has been illustrated with regard to the intermembral index. It has been repeatedly pointed out in the preceding descriptions that the measurements themselves are necessary to show what makes the indices vary. The low palate length-breadth index of the male macaques might be due to a narrow palate. In reality the macaques' palate is much wider than the langurs', but it is so much longer that the index is still low. The low scapular index of the langurs is due primarily to their shorter morphological length. The differences in several pelvic indices depend largely on ischiatic length.

The importance of the actual measurement is well illustrated in the comparison of the proportionate length of the spinal regions of higher and lower catarrhines. As Keith (1902) and Schultz (1938) have shown, in percent of pre-sacral spine length, the cervical and thoracic regions of lower catarrhines are short and the lumbar region long. In the higher catarrhines the cervical and thoracic regions are long and the lumbar short. As Keith pointed out, these differences are due almost entirely to the difference in the lumbar region. This is short in the higher catarrhines, therefore the percentage of the pre-sacral spine composed by the cervical and thoracic regions must be higher. In this way three percentage differences are primarily due to a change in one measurement, and this is not obvious unless the actual measurements are available.

By the methods used in this paper the comparison of the higher and lower catarrhines can be simplified from a comparison of a vast number of indices to that of a very few measurements. These measurements are the ones which underlie the proportions which separate the two groups with no overlapping. In the case of the higher and lower catarrhines, the measurements which are responsible for these greatest differences are those most closely associated with the differences in locomotion. The long lumbar region of the monkeys with the well-marked anticlinal vertebra is typical of small, active quadrupeds. The

long upper extremities of the higher catarrhines are associated with brachiation.

SUMMARY

The greatest proportional differences between these langurs and macaques are as follows: The macaques have larger skulls and particularly larger facial skeletons. The part of the face that is larger is the part which supports the teeth, not the orbital or interorbital portions. The nasal bones of the macaques are long and the internasal suture closes early. The nasals of the langurs are short and the internasal suture closes late. The cranial capacity of the macaques is larger.

The sternum is longer relative to the thorax in the macaques and is composed of six or seven separate elements, not counting the xiphoid process. The langur's sternum is composed of five or six sternaebrae which may unite (particularly in maroon langurs) until only two are left. The corpus sterni is much wider in the langurs.

The clavicle of the macaques is longer relative to thoracic length. The macaque's scapula is longer, narrower, and the supraspinous fossa is relatively wider.

The pelvis of the macaques is relatively larger, all three component parts being longer relative to weight or thoracic length. The macaque's ischium is 20 percent longer compared to femur length.

The intermembral index of the macaques is higher than that of the langurs because the langurs have longer hind limbs. The brachial index of the macaques is intermediate.

In both hands and feet the lateral digits are longer in the langurs and the medial longer in the macaques. Rarely, in the crested langurs, the os centrale may unite with the scaphoid.

Variation may be used to concentrate attention on the greatest differences, thus simplifying comparisons.

Proportional differences between higher and lower catarrhines are principally in the lumbar region and upper extremity, associated with differences in locomotion.

More well-documented series of monkeys are needed to test these conclusions and methods.

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CRANIAL CAPACITIES BY BOTH PLASTIC AND WATER TECHNIQUES WITH CRANIAL LINEAR MEASUREMENTS OF THE RESERVE COLLECTION; WHITE AND NEGRO*

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THE data upon which this report is based are from the permanent records of the Department of Anatomy, Western Reserve University School of Medicine, All measurements were made by, or under the direction of, the late T. Wingate Todd, Professor of Anatomy from 1912 until his death in December, 1938. The analysis reported here was made in 1939 by the author.

Over a long period of years Professor Todd had an active interest in the problem of the measuring error attending direct estimation of cranial capacity and in the problem of the prediction of cranial capacity from external linear measurements of the skull by mathematical formula. The method of measuring cranial capacity by the use of plastic material was devised by him in 1926 because of his dissatisfaction with the error he obtained with use of seed and water media. At the time only very small series of skulls were subjected to this technique but sufficient experimentation was done by Professor Todd and his students to satisfy him that the plastic method need produce a measuring error no greater than 10 cc. Convinced of the method's superiority over the water method then in use in this laboratory he had his assistants make capacity measurements by the plastic method of all the dried, macerated skulls in the Reserve collection at that time and such measurements were made routinely on all skulls obtained thereafter. For some years, however, he continued to measure capacities of the wet,

* Based on the methods and data developed by T. Wingate Todd, late Professor of Anatomy, Western Reserve University.

unmacerated skulls by the water method both with membranes intact and with membranes removed. Consequently, three series of measurements made on the same skulls were recorded, one series made by the plastic technique and two series made by the water technique.

On file in this laboratory with the measurement records are notes, written (*ca.* 1927) by Professor Todd, expressing his reasons for selecting a plastic material for the purpose of estimating capacity of the skull. Excerpts from these notes follow:

"We have read with admiration the excellent accounts of reliability of their technique given by such authors as have been self critical enough to publish a validation but we must confess that we have never attained such precision. This cannot be lack of practice for we have subjected 1,000 skulls to estimation and re-estimation by Hrdlička's seed method, by our own water method and by the method shortly to be described. At the end of this very considerable expenditure of time, energy and money we have to admit that by water or seed we do not know that our estimate is any nearer than 40 cc. above or below the real capacity. We came to this conclusion reluctantly after the most assiduous checking and re-checking of each other by the several methods not content with anything short of absolute conviction.

"In coming to this conclusion we have not failed to train ourselves by the adoption of crânes étalons. But being interested also in the psychological aspect of our investigation we have found that conditioned reflexes are very easily set up and throw the unsuspecting investigator into error. We have practiced with our standard skulls until we could perform the technique and time after time secure results within 5 cc. of each other. Then we would apply ourselves to a random series of skulls and obtain no more reliable results than before. The crâne étalon is the best example possible of a scientific Barmecide. Its much vaunted advantages are wholly illusory.

"We set out to find, if possible, another substance which might be utilized in the actual measurement of cranial capacity. The needs are: a non-compressible plastic substance; applicability to skull in wet or dry condition fresh or macerated; availability for all skulls no matter how they are cut. One would like to add of course that the substance be suitable for use even if the skull be not cut. Those who have had considerable experience, however, understand how difficult it is to obtain adequate filling of the anterior and middle fossae when the skull is intact, how difficult it is to maintain uniform pressure throughout the mass inserted unless it be water, and lastly how difficult it is to know when these requirements have all been met. We are not therefore greatly concerned about the last item, desirable though it be.

"In 1926 after many experiments we came to the conclusion that some dextrin compound would probably be the most serviceable for our purpose. It is not heavy, is easily worked into difficult places, is not compressible so as to make different pressure in different areas, and is readily removed again. The handiest form in which dextrin can be obtained commercially is Climax wall paper cleaner. For

those to whom the commercial compound is inaccessible we give the method of manufacture.

"Mix well best flour 82 lbs., powdered alum 18 oz., common salt 37.5 lbs. Then add slowly a mixture of water 7 gal. in which has been dissolved gum arabic 14 oz., paraffin oil (coal oil) 15 oz., red color 11 oz. This mixture is stirred into well vaselined pans and cooked for 30 minutes in steamers at 200° F."

MATERIAL

For analysis there were used measurements of 2241 skulls, 1179 male white, 661 male Negro, 182 female white and 219 female Negro. Included were all skulls in the Reserve collection obtained from 1910 through 1936 for which were available external linear measurements and an estimate of cranial capacity by the plastic technique and whose chronological age was known or estimated to be 20 years or more. The entire skull collection was inspected by Mr. R. S. Baby and skulls found to have been damaged in any way that would affect cranial measurements were eliminated from the study. All skulls had been bisected before measurement; a small number had been cut in the supraorbital plane for removal of the calvarium at autopsy but the greater number had been divided in the median sagittal plane according to the technique described by Todd (7). Skulls were classified as white or Negro according to information on the death certificate.

MEASUREMENTS

The frequencies of observations made of the several measurements are listed in Table 1.

TECHNIQUES AND OBSERVERS

External cranial measurements. Linear measurements were made on dried, macerated skulls by Professor Todd, M. S. Fiala, G. Williams, W. H. Maryanski, and R. S. Baby. Cranial length and auricular height were measured with the Reserve craniostat, the skull fixed in the Frankfort plane, according to the techniques described by Todd (7). Maximum breadth was determined with Flower's craniometer.

Cranial capacity, plastic technique. Measurements were made on dried, macerated skulls by R. M. McMichael, G. Williams, M. S. Fiala, G. Evans, F. B. Webster, R. Mansfield, T. Rosen, W. H. Maryanski, and R. S. Baby. By experiment it was found that the density of the wall paper cleaner varies slightly with humidity, changes slightly

TABLE 1

Number of observations for each variable, male white, male Negro, female white, female Negro

VARIABLE	MALE WHITE *N*	MALE NEGRO *N*	FEMALE WHITE *N*	FEMALE NEGRO *N*	UNITS
Cranial length, supraorbital....	1179	661	182	219	Mm.
Cranial length, glabellar.....	1179	661	182	219	Mm.
Cranial breadth, maximum.....	1179	661	182	219	Mm.
Cranial height, auricular.....	1179	661	182	219	Mm.
Cranial index	1179	661	182	219	....
Cranial capacity, plastic method	1179	661	182	219	Cc.
Cranial capacity, water method with membranes intact.....	668	455	112	157	Cc.
Cranial capacity, water method with membranes removed..	668	455	112	157	Cc.
Dura volume	668	455	112	157	Cc.
Body length	668	455	112	157	Mm.

with use and varies, when fresh, among can samples. It was made a routine practice, therefore, to obtain and record the specific gravity of the material each day before use and if use was prolonged over a day's period, to obtain and record the specific gravity at the beginning of each half day. The specific gravity having been obtained, the mass of wall paper cleaner was well kneaded to ensure removal of bubbles and then packed into each separate half of the skull. Excess material was carefully removed from all foramina and the surface of the material was levelled with the cut edge of the skull, a spatula being used for this purpose.

The following sources of error in making capacity measurements by the plastic technique were considered by Professor Todd to be particularly important:

1. Failure to pack the plastic material properly into the skull.
2. Failure to cut the excess off in the same direction in each half of the skull.
3. Failure to use small strokes when removing excess.
4. Failure to remove excess from all foramina.
5. Failure to get a smooth, flat surface which by the knife edge test is level with the cut edge of the skull.
6. Failure to approximate the cut surfaces of the two halves. There should be less than 1 mm. distance between the two surfaces.

7. Failure to have the balances set at "0" before measurements are made.
8. Failure to check the weights as they are removed from the pan.
9. Failure to knead the ball of plastic material into a smooth, bubbleless mass before packing it into the skull.

When an observer was trained in the plastic technique he measured skulls which had been measured previously by an experienced observer; the occurrence of a difference greater than 10 cc. between the capacity measurements by the plastic method of the same skull by the two observers was considered cause for re-estimation.

TABLE 2

Means and constants of varibility of cranial linear measurements, cranial capacity measurements, cranial index and body length, male white

VARIABLE	*N*	*M*	σ	*V*	RANGE
		Total			
Length, S.O.....	1179	182.63	7.65	4.19	159 to 211
Length, glabellar.....	1179	181.91	7.61	4.18	158 to 210
Breadth, maximum....	1179	144.58	5.86	4.05	123 to 164
Height, auricular.....	1179	115.83	4.55	3.93	102 to 133
Cranial index.....	1179	79.67	4.43	5.56	62.4 to 93.0
Capacity, plastic.....	1179	1452.27	116.76	8.04	1099 to 1782
		Complete			
Length, S.O.....	668	182.40	7.46	4.09	159 to 205
Length, glabellar.....	668	181.67	7.44	4.10	158 to 204
Breadth, maximum.....	668	144.58	5.81	4.02	123 to 164
Height, auricular.....	668	115.66	4.55	3.93	102 to 133
Capacity, plastic.....	668	1447.12	115.83	8.00	1099 to 1776
Capacity, water, Membranes intact....	668	1462.24	119.94	8.20	1067 to 1780
Capacity, water, Membranes removed	668	1517.49	122.84	8.09	1110 to 1866
Dura volume.....	668	54.51	8.35	15.32	35 to 101
Body length.....	668	1711.37	69.58	4.06	1515 to 1925
		Incomplete			
Length, S.O.....	511	182.93	7.89	4.31	161 to 211
Length, glabellar.....	511	182.23	7.81	4.29	160 to 210
Breadth, maximum....	511	144.58	5.94	4.11	127 to 160
Height, auricular.....	511	116.05	4.55	3.92	103 to 132
Capacity, plastic.....	511	1458.99	117.62	8.06	1140 to 1782

Cranial capacity, water technique and volume of the dura. All cranial capacity measurements by the water technique (made on wet, unmacerated skulls, bisected in the median sagittal plane), both with membranes removed and with membranes intact, and all measurements of the volume of the dura were made by Professor Todd according to the techniques he described (7). Each capacity measurement by water technique used in this analysis represents an average of five determinations.

TABLE 3

Means and constants of varibility of cranial linear measurements, cranial capacity measurements, cranial index and body length, male Negro

VARIABLE	*N*	*M*	σ	*V*	RANGE
		Total			
Length, S.O.	661	187.35	6.73	3.59	168 to 225
Length, glabellar	661	186.90	6.71	3.59	168 to 224
Breadth, maximum	661	138.68	5.58	4.02	120 to 157
Height, auricular	661	114.58	4.64	4.05	99 to 133
Cranial index	661	74.34	3.43	4.62	61.7 to 84.1
Capacity, plastic	661	1388.74	118.25	8.51	1030 to 1886
		Complete			
Length, S.O.	455	187.40	7.00	3.74	170 to 225
Length, glabellar	455	186.96	6.97	3.73	170 to 224
Breadth, maximum	455	138.56	5.52	3.98	120 to 157
Height, auricular	455	114.42	4.47	3.91	103 to 128
Capacity, plastic	455	1384.68	119.18	8.61	1074 to 1886
Capacity, water, Membranes intact	455	1411.65	122.76	8.70	1089 to 1959
Capacity, water, Membranes removed	455	1467.13	125.46	8.55	1117 to 2022
Dura volume	455	53.88	7.15	13.28	32 to 81
Body length	455	1749.71	76.10	4.35	1505 to 1975
		Incomplete			
Length, S.O.	206	187.23	6.10	3.26	168 to 207
Length, glabellar	206	186.76	6.10	3.26	168 to 207
Breadth, maximum	206	138.95	5.70	4.10	122 to 155
Height, auricular	206	114.95	4.97	4.32	99 to 133
Capacity, plastic	206	1397.70	115.66	8.28	1030 to 1687

Body Length. Body length was measured by Professor Todd.

ANALYSIS

In the statistical analysis of the data the punched card method was used with the International Business Machines equipment in the Brush Foundation. The tabulating card carried the raw cranial data, no coding having been done except of the measurements of body length which were classified in 10 mm. intervals.

Constants of central tendency and variability in the dimensions described for the four sex-color groups are shown in Tables 2 (male white), 3 (male Negro), 4 (female white) and 5 (female Negro).

TABLE 4

Means and constants of varibility of cranial linear measurements, cranial capacity measurements, cranial index and body length, female white

VARIABLE	*N*	*M*	σ	*V*	RANGE
		Total			
Length, S.O.	182	174.01	7.00	4.02	157 to 193
Length, glabellar	182	173.68	6.96	4.01	157 to 193
Breadth, maximum	182	139.22	5.56	3.99	123 to 154
Height, auricular	182	110.94	3.83	3.45	103 to 122
Cranial index	182	80.34	4.30	5.35	70.5 to 92.0
Capacity, plastic	182	1274.63	111.25	8.73	1070 to 1749
		Complete			
Length, S.O.	112	173.86	6.34	3.64	158 to 190
Length, glabellar	112	173.46	6.31	3.64	157 to 190
Breadth, maximum	112	139.28	5.82	4.18	123 to 154
Height, auricular	112	110.88	4.02	3.62	103 to 122
Capacity, plastic	112	1276.39	112.62	8.82	1070 to 1794
Capacity, water, Membranes intact	112	1292.15	119.61	9.26	1078 to 1807
Capacity, water, Membranes removed	112	1338.82	122.92	9.18	1104 to 1870
Dura volume	112	45.62	7.20	15.79	27 to 68
Body length	112	1591.91	76.72	4.82	1365 to 1845
		Incomplete			
Length, S.O.	70	174.26	7.94	4.56	157 to 193
Length, glabellar	70	174.01	7.87	4.52	157 to 193
Breadth, maximum	70	139.14	5.12	3.68	126 to 152
Height, auricular	70	111.04	3.51	3.16	104 to 120
Capacity, plastic	70	1271.80	108.97	8.57	1049 to 1619

TABLE 5

Means and constants of varibility of cranial linear measurements, cranial capacity measurements, cranial index and body length, female Negro

VARIABLE	*N*	*M*	σ	*V*	RANGE
		Total			
Length, S.O.	219	180.05	6.08	3.38	168 to 201
Length, glabellar	219	179.86	6.06	3.37	167 to 201
Breadth, maximum	219	134.47	5.13	3.81	117 to 149
Height, auricular	219	110.16	4.07	3.69	100 to 120
Cranial index	219	74.88	3.12	4.16	64.5 to 82.8
Capacity, plastic	219	1238.08	100.73	8.14	993 to 1583
		Complete			
Length, S.O.	157	179.98	6.13	3.41	168 to 201
Length, glabellar	157	179.80	6.12	3.40	167 to 201
Breadth, maximum	157	134.52	5.19	5.19	117 to 149
Height, auricular	157	110.22	4.00	3.63	102 to 119
Capacity, plastic	157	1235.80	98.22	7.95	993 to 1480
Capacity, water, Membranes intact	157	1264.86	99.62	7.88	1036 to 1522
Capacity, water, Membranes removed	157	1310.94	103.72	7.91	1077 to 1569
Dura volume	157	44.87	6.84	15.25	22 to 63
Body length	157	1638.96	64.76	3.95	1495 to 1825
		Incomplete			
Length, S.O.	62	180.24	5.94	3.30	169 to 199
Length, glabellar	62	180.02	5.90	3.28	169 to 198
Breadth, maximum	62	134.37	4.96	3.69	126 to 148
Height, auricular	62	110.03	4.22	3.84	100 to 120
Capacity, plastic	62	1243.84	106.60	8.57	1036 to 1583

In each table the three sections denote first (Total) the entire number available for the external measurements and capacity by the plastic method, second (Complete group) the number available for all nine variables, and third (Incomplete group) the number of external measurements and capacity measurements by the plastic method remaining after the second section is deleted, or the first section minus the second section. The mean differences between cranial capacity measured by the water method on the wet, unmacerated skull with the membranes intact and by the water method on the wet, unmacerated skull

with the membranes removed range from 46.08 cc. (female Negro) to 55.25 cc. (male white). There is a consistent sex difference in this respect, both male groups showing greater differences (55.25 cc., 55.48 cc.) than the two female groups (46.67 cc., 46.08 cc.).

In an early study Todd (8) stated that the volume of the membranes in the fresh skull is, on the average, nearly equal to the decrease in volume caused by shrinkage of the macerated skull in drying, or from 50 to 60 cc. Accordingly, the capacity of the dried, macerated skull should nearly equal the capacity of the wet, unmacerated skull with membranes intact. In the samples described here the mean differences between cranial capacity measured by the water method on the wet, unmacerated skull with membranes intact and by the plastic method on the dried, macerated skull range from 15.12 cc. (male white) to 29.06 cc. (female Negro). There is a consistent color difference in this respect, both Negro groups showing a greater difference (26.97 cc., 29.06 cc.) than the two white groups (15.12 cc., 15.76 cc.). For all four sex-color groups the differences, cranial capacity measured by the water method on the wet skull with membranes intact minus cranial capacity measured by the plastic method on the dried skull, are statistically significant, the difference—standard error of the difference ratios being 10.72 for male white, 13.55 for male Negro, 4.60 for female white and 10.28 for female Negro. Estimates of cranial capacity by use of the plastic technique represent therefore a sampling of a different population of measurements from the estimates obtained by the water technique. The high correlations found between the capacity estimates obtained by the two methods contribute to the large critical ratios. It may be that the differences of 15.12 cc. and 15.76 cc. are of little or no practical importance despite their statistical significance.

The known heterogeneity of a population of the indigent dead of such a city as Cleveland, where there are large groups of diverse national derivation, is reflected in the variability constants which tend to be considerably greater than those reported on relatively more homogeneous groups, as for example, the Eskimos studied by Cameron (2). The variability of Reserve whites tends to exceed that of Reserve Negroes. The variability constants of Reserve whites are, however, but little greater than and in some measures are less than those reported by Lee and Pearson (5) on Bavarians (Ranke's data), by Benington

(1) and Isserlis (4) on African Negroes, and by Herskovits (3) on cephalic measurements of living American Negroes.

The mean dura volume as determined directly by the water displacement method can be compared in Table 6 with the indirect estimate of volume of the dura (mean cranial capacity by the water method with membranes removed minus mean cranial capacity by the water method

TABLE 6

Means of dura volume measured directly compared with dura volume obtained indirectly as the difference between mean cranial capacity by water method with membranes removed and mean cranial capacity by water method with membranes intact

N	GROUP	1 MEAN CAPACITY MEMBRANES REMOVED	2 MEAN CAPACITY MEMBRANES INTACT	3 DIFF. 1–2	4 MEAN DURA VOLUME DIRECT	5 DIFF. 3–4
668	Male white	1517.49	1462.24	55.25	54.51	0.74
455	Male Negro	1467.13	1411.65	55.48	53.88	1.60
112	Female white	1338.82	1292.15	46.67	45.62	1.05
157	Female Negro	1310.94	1264.86	46.08	44.87	1.21

with membranes intact. For all four sex-color groups the dura volume obtained indirectly is greater than the direct measurement, the differences ranging from 0.74 cc. (male white) to 1.60 cc. (male Negro).

Male-female and white-Negro differences with their statistical significance appear in Table 7. The males of both racial groups are significantly larger than the females in all variables except cranial index in which the females exceed the males by an insignificant amount. The racial differences are consistent in direction for both sexes but not all differences are significant. The Negroes of both sexes exceed the whites in cranial length and body length, the whites of both sexes exceed the Negroes in cranial breadth, height and capacity, volume of the dura and cranial index. The only insignificant differences between the two male groups occur in volume of the dura for the complete group and in cranial height for the incomplete group. The

small numbers in the two female samples contribute to the greater frequency of occurrence of insignificant differences between these two racial samples. With but one exception, the volume of the dura, sex differences are greater in whites than in Negroes.

In Table 8 are shown five-categoried frequency distributions of

TABLE 7

Significance of sex and racial differences between means of cranial linear measurements, cranial capacity measurements, cranial index and body length

	*MALE WHITE MALE NEGRO		*FEMALE WHITE FEMALE NEGRO		*MALE WHITE FEMALE WHITE		*MALE NEGRO FEMALE NEGRO	
	d	$\frac{d}{\sigma d}$	d	$\frac{d}{\sigma d}$	d	$\frac{d}{\sigma d}$	d	$\frac{d}{\sigma d}$
Total								
Length, S.O.	4.72	13.85	6.04	9.12	8.62*	15.27	7.30*	15.04
Length, glabellar	4.99	14.65	6.18	9.33	8.23*	14.58	7.04*	14.50
Breadth	5.90*	21.22	4.75*	8.81	5.36*	12.08	4.21*	10.18
Height	1.25*	5.63	0.78*	2.00	4.89*	15.84	4.42*	13.62
Capacity, plastic	63.53*	11.11	36.55*	3.42	177.64*	19.91	150.66*	18.33
Cranial index	5.33*	28.70	5.46*	14.30	0.67	1.95	0.54	2.16
Complete								
Length, S.O.	5.00	11.38	6.12	7.90	8.54*	12.82	7.42*	12.56
Length, glabellar	5.29	12.04	6.34	8.18	8.21*	12.32	7.16*	12.12
Breadth	6.02*	17.67	4.76*	6.94	5.30*	8.95	4.04*	8.32
Height	1.24*	4.48	0.66*	1.33	4.78*	11.37	4.20*	10.97
Capacity, plastic	62.44*	8.72	40.59*	3.07	170.73*	14.79	148.88*	15.46
Capacity, water Membranes intact	50.59*	6.84	27.29*	1.98	170.09*	13.92	146.79*	14.95
Capacity, water Membranes removed	50.36*	6.66	27.88*	1.96	178.67*	14.24	156.19*	15.38
Dura volume	0.63*	1.35	0.75*	0.86	8.89*	11.83	9.01*	13.93
Body length	38.34	8.58	47.05	5.28	119.46*	15.45	110.75*	17.63
Incomplete								
Length, S.O.	4.30	7.86	5.98	4.94	8.67*	8.56	6.99*	8.13
Length, glabellar	4.53	8.38	6.01	5.00	8.22*	8.22	6.74*	7.84
Breadth	5.63*	11.80	4.77*	5.48	5.44*	8.20	4.58*	6.14
Height	1.10*	2.73	1.01*	1.48	5.01*	10.77	4.92*	7.64
Capacity, plastic	61.29*	6.39	27.96*	1.49	187.19*	13.35	153.86*	9.76

* Greater mean.

TABLE 8

Five-category frequency distributions of cranial index, male white, male Negro, female white, female Negro

	CRANIAL INDEX	*N*	PERCENT	CLASSIFICATION
Male white	69.9 and below	9	.76	Hyperdolicocephalic
$N = 1179$	70 to 74.9	170	14.42	Dolicocephalic
	75 to 79.9	467	39.61	Mesocephalic
	80 to 84.9	381	32.32	Brachycephalic
	85 and above	152	12.89	Hyperbrachycephalic
Male Negro	69.9 and below	61	9.23	Hyperdolicocephalic
$N = 661$	70 to 74.9	325	49.17	Dolicocephalic
	75 to 79.9	246	37.22	Mesocephalic
	80 to 84.9	29	4.39	Brachycephalic
	85 and above	0	.00	Hyperbrachycephalic
Female white	69.9 and below	0	.00	Hyperdolicocephalic
$N = 182$	70 to 74.9	20	10.99	Dolicocephalic
	75 to 79.9	70	38.46	Mesocephalic
	80 to 84.9	65	35.71	Brachycephalic
	85 and above	27	14.84	Hyperbrachycephalic
Female Negro	69.9 and below	12	5.48	Hyperdolicocephalic
$N = 219$	70 to 74.9	99	45.21	Dolicocephalic
	75 to 79.9	100	45.66	Mesocephalic
	80 to 84.9	8	3.65	Brachycephalic
	85 and above	0	.00	Hyperbrachycephalic

cranial index for the four sex-color groups. The racial difference is marked; 45 percent of the male whites and 50 percent of the female whites are characterized by a cranial index of 80 or greater (brachycephaly), whereas 58 percent of the male Negroes and 50 percent of the female Negroes are characterized by an index of 74.9 or less (dolichocephaly). The cranial index is the variable showing the most significant racial difference and it is the only variable in which the sex difference is insignificant.

Zero-order correlation coefficients among all variables with the data classified in three sets, Total, Complete and Incomplete as before, appear in Tables 9 (male white), 10 (male Negro), 11 (female white) and 12 (female Negro). The correlations between the two measures

of cranial capacity by the water method are of the same magnitude as the correlations between the two measures of cranial length, all being greater than 0.99. The correlations between cranial capacity by the water method and cranial capacity by the plastic method range from 0.94 to 0.96, indicating a degree of relationship between the results

TABLE 9

Zero-order intercorrelation coefficients among cranial linear measurements, cranial capacity measurements, body length, male white

	LENGTH GLABELLAR	BREADTH	HEIGHT	CAPACITY PLASTIC	CAPACITY WATER MEM. INTACT	CAPACITY WATER MEM. REMOVED	DURA VOLUME	BODY LENGTH
				Total				
$N = 1179$								
Length, S.O.	0.996	0.096	0.296	0.564	....	....	....	....
Length, glabellar	....	0.094	0.296	0.560	....	....	....	....
Breadth	....	....	0.418	0.604	....	....	....	....
Height	....	....	....	0.644	....	....	....	....
				Complete				
$N = 668$								
Length, S.O.	0.996	0.100	0.287	0.545	0.513	0.515	0.220	0.295
Length, glabellar	....	0.097	0.283	0.540	0.511	0.513	0.220	0.297
Breadth	....	....	0.445	0.622	0.594	0.606	0.245	0.044
Height	....	....	....	0.655	0.653	0.656	0.230	0.139
Capacity, plastic	....	....	....	....	0.953	0.957	0.336	0.211
Capacity, water Mem. intact	....	....	....	....	....	0.995	0.298	0.235
Capacity, water Mem. removed	....	....	....	....	....	....	0.359	0.231
Dura volume	....	....	....	....	....	....	....	0.080
				Incomplete				
$N = 511$								
Length, S.O.	0.997	0.090	0.306	0.587	....	....	....	....
Length, glabellar	....	0.090	0.309	0.584	....	....	....	....
Breadth	....	....	0.385	0.585	....	....	....	....
Height	....	....	....	0.628	....	....	....	....

obtained by the two techniques comparable with a generally acceptable reliability coefficient obtained from repetition of the same technique by the same observer, despite the differences between the crainal capacity means of the two series which have been shown to be statistically significant.

TABLE 10

Zero-order intercorrelation coefficients among cranial linear measurements, cranial capacity measurements, body length, male Negro

	LENGTH GLABELLAR	BREADTH	HEIGHT	CAPACITY PLASTIC	CAPACITY WATER MEM. INTACT	CAPACITY WATER MEM. REMOVED	DURA VOLUME	BODY LENGTH
				Total				
$N = 661$								
Length, S.O.	0.996	0.280	0.396	0.571	....	....	....	....
Length, glabellar	....	0.270	0.390	0.568	....	....	....	....
Breadth	....	....	0.407	0.647	....	....	....	....
Height	....	....	....	0.646	....	....	....	....
				Complete				
$N = 455$								
Length, S.O.	0.996	0.293	0.401	0.573	0.598	0.607	0.272	0.295
Length, glabellar	....	0.282	0.394	0.568	0.595	0.603	0.272	0.297
Breadth	....	....	0.424	0.654	0.626	0.634	0.350	0.196
Height	....	....	....	0.641	0.605	0.610	0.300	0.129
Capacity, plastic	....	....	....	....	0.939	0.943	0.394	0.169
Capacity, water Mem. intact	....	....	....	....	....	0.995	0.327	0.218
Capacity, water Mem. removed	....	....	....	....	....	....	0.375	0.216
Dura volume	....	....	....	....	....	....	....	0.036
				Incomplete				
$N = 206$								
Length, S.O.	0.995	0.252	0.398	0.574	....	....	....	....
Length, glabellar	....	0.245	0.395	0.575	....	....	....	....
Breadth	....	....	0.372	0.631	....	....	....	....
Height	....	....	....	0.659	....	....	....	....

The intercorrelations among the external linear measurements tend to be somewhat higher in the Negro than in the white samples. This slight difference is reflected in the multiple correlations (Table 13) of cranial length (glabellar), cranial breadth and cranial height with the criterion cranial capacity, the *R*'s tending to be slightly higher

TABLE 11

Zero-order intercorrelation coefficients among cranial linear measurements, cranial capacity measurements, body length, female white

	LENGTH GLABELLAR	BREADTH	HEIGHT	CAPACITY PLASTIC	CAPACITY WATER MEM. INTACT	CAPACITY WATER MEM. REMOVED	DURA VOLUME	BODY LENGTH
				Total				
$N = 182$								
Length, S.O.	0.996	0.134	0.368	0.574	....	....	....	....
Length, glabellar	....	0.131	0.368	0.576	....	....	....	....
Breadth	....	....	0.474	0.617	....	....	....	....
Height	....	....	....	0.638	....	....	....	....
				Complete				
$N = 112$								
Length, S.O.	0.995	0.110	0.260	0.474	0.401	0.395	0.234	0.290
Length, glabellar	....	0.105	0.258	0.478	0.408	0.402	0.235	0.293
Breadth	....	....	0.514	0.674	0.698	0.699	0.308	0.085
Height	....	....	....	0.610	0.629	0.629	0.266	0.334
Capacity, plastic	....	....	....	....	0.953	0.952	0.416	0.245
Capacity, water Mem. intact	....	....	....	....	....	0.997	0.405	0.274
Capacity, water Mem. removed	....	....	....	....	....	....	0.453	0.262
Dura volume	....	....	....	....	....	....	....	0.019
				Incomplete				
$N = 70$								
Length, S.O.	0.998	0.175	0.540	0.719	....	....	....	....
Length, glabellar	....	0.176	0.544	0.719	....	....	....	....
Breadth	....	....	0.394	0.511	....	....	....	....
Height	....	....	....	0.696	....	....	....	....

for male white than for male Negro and slightly higher for female white than for female Negro samples. (Multiple correlations were computed by the Doolittle method.) The R's between the criterion, cranial capacity by plastic technique, and the three external measurements for the total number of cases in each of the four sex-color

TABLE 12

Zero-order intercorrelation coefficients among cranial linear measurements, cranial capacity measurements, body length, female Negro

	LENGTH GLABELLAR	BREADTH	HEIGHT	CAPACITY PLASTIC	CAPACITY WATER MEM. INTACT	CAPACITY WATER MEM. REMOVED	DURA VOLUME	BODY LENGTH
				Total				
$N = 219$								
Length, S.O.	0.998	0.323	0.441	0.596	....	....	....	....
Length, glabellar	....	0.317	0.440	0.597	....	....	....	....
Breadth	....	....	0.442	0.594	....	....	....	....
Height	....	....	....	0.633	....	....	....	....
				Complete				
$N = 157$								
Length, S.O.	0.998	0.313	0.452	0.557	0.530	0.527	0.099	0.344
Length, glabellar	....	0.302	0.452	0.561	0.535	0.532	0.104	0.339
Breadth	....	....	0.462	0.590	0.545	0.547	0.204	0.160
Height	....	....	....	0.663	0.587	0.601	0.304	0.278
Capacity, plastic	....	....	....	....	0.936	0.939	0.414	0.329
Capacity, water Mem. intact	....	....	....	....	....	0.995	0.373	0.313
Capacity, water Mem. removed	....	....	....	....	....	....	0.416	0.331
Dura volume	....	....	....	....	....	....	....	0.100
				Incomplete				
$N = 62$								
Length, S.O.	0.998	0.354	0.417	0.691	....	....	....	....
Length, glabellar	....	0.359	0.411	0.688	....	....	....	....
Breadth	....	....	0.393	0.611	....	....	....	....
Height	....	....	....	0.570	....	....	....	....

TABLE 13

Multiple correlation coefficients between the criterion cranial capacity and the three linear measurements, male white, male Negro, female white, female Negro

	MALE WHITE		MALE NEGRO		FEMALE WHITE		FEMALE NEGRO	
	N	*R*	*N*	*R*	*N*	*R*	*N*	*R*
$R_{C \cdot LBH}$	= 1179	0.843	661	0.824	182	0.827	219	0.785
Plastic								
$R_{C \cdot LBH}$	= 668	0.843	455	0.820	112	0.817	157	0.780
Plastic								
$R_{C \cdot LBH}$	= 668	0.816	455	0.803	112	0.812	157	0.719
Water-mem. intact								
$R_{C \cdot LBH}$	= 668	0.823	455	0.812	112	0.810	157	0.721
Water-mem. removed								

groups range from 0.785 (female Negro) to 0.843 (male white). These *R*'s, although indicating a high degree of group predictability, are, however, all too low for efficient individual prediction and indicate that the cranial capacity of these population samples cannot be predicted efficiently from measurements of their cranial length, breadth and height.

TABLE 14

Multiple regression equations for prediction of cranial capacity (plastic) from the three cranial linear measurements, male white, male Negro, female white, female Negro

Male white	$N = 1179$
	$C = 6.43\ L + 8.39\ B + 8.83\ H - 1953.22$
Male Negro	$N = 661$
	$C = 5.60\ L + 8.86\ B + 8.97\ H - 1914.39$
Female white	$N = 182$
	$C = 6.65\ L + 8.58\ B + 8.16\ H - 1980.12$
Female Negro	$N = 219$
	$C = 5.72\ L + 6.64\ B + 8.22\ H - 1589.12$

TABLE 15

Frequency distributions of prediction errors (measured plastic capacity minus predicted capacity), male white, male Negro, female white, female Negro

PREDICTION ERROR *cc.*	MALE WHITE *N*	MALE NEGRO *N*	FEMALE WHITE *N*	FEMALE NEGRO *N*
−250 to −241	..	1	1	..
240 to 231	..	..	..	..
230 to 221	..	..	..	..
220 to 211	..	..	..	..
210 to 201	..	..	..	..
200 to 191	1	1	..	..
190 to 181	2	..	..	1
180 to 171	2	..	1	..
170 to 161	4	1	..	..
160 to 151	5	3	2	..
150 to 141	4	6	1	3
140 to 131	7	6	..	..
130 to 121	6	5	..	1
120 to 111	16	11	1	1
110 to 101	18	13	1	5
100 to 91	26	10	3	7
90 to 81	22	19	3	3
80 to 71	45	24	8	3
70 to 61	40	24	4	9
60 to 51	52	22	10	12
50 to 41	52	35	4	10
40 to 31	56	33	12	14
30 to 21	70	28	13	13
20 to 11	70	41	11	13
− 10 to − 1	83	42	16	12
0 to + 9	78	36	16	12
+ 10 to +19	78	37	13	19
20 to 29	72	45	13	18
30 to 39	67	37	7	7
40 to 49	53	31	5	10
50 to 59	50	27	11	13
60 to 69	47	32	3	7
70 to 79	37	22	6	6
80 to 89	33	16	2	6
90 to 99	20	11	3	3
100 to 109	15	12	3	1

TABLE 15 *(Continued)*

PREDICTION ERROR cc.	MALE WHITE N	MALE NEGRO N	FEMALE WHITE N	FEMALE NEGRO N
+110 to +119	13	9	2	3
120 to 129	8	3	1	1
130 to 139	8	5	2	..
140 to 149	7	1	3	3
150 to 159	2	4	..	..
160 to 169	5	1	..	1
170 to 179	3	2	..	..
180 to 189	2	2	..	..
190 to 199	..	..	1	..
200 to 209	..	1	..	1
210 to 219	..	..	..	1
+220 to +229	..	2	..	..
Total	1179	661	182	219

Nevertheless, the magnitude of the errors actually found between measured capacity and capacity predicted by formula from the three external measurements seemed of sufficient interest to warrant computation of the formulae and derivation of the errors. A multiple regression formula was computed for each of the four sex-color groups; the four formulae appear in Table 14. The predicted capacity of each of the 2241 skulls was obtained and the differences determined between predicted capacity and measured capacity (by plastic technique). The frequency distributions in 10 cc. intervals of the

TABLE 16

Prediction error means (without sign) and ranges (with sign), male white, male Negro, female white, female Negro

PREDICTION ERROR	MALE WHITE	MALE NEGRO	FEMALE WHITE	FEMALE NEGRO
Mean (without sign)	49.69	53.14	46.63	49.08
Range (with sign)	−194.24 to +188.60	−244.40 to +227.87	−243.58 to +189.72	−182.56 to +218.08

resultant prediction errors for the four sex-color groups appear in Table 15. Table 16 shows the mean prediction error (without sign) and the range of error for the four groups. The errors at both extremes are large, the distributions tending to approximate the expected normal curve of error. The spread of the male white distribution is smallest, that of the male Negro distribution greatest, the latter ranging from — 244.4 to + 227.87 cc.

Among the skulls of this collection numerous examples can be found of skulls whose length, breadth and height are identical or closely similar but whose measured capacities are widely divergent. The measurements of a few pairs of skulls which exemplify this condition are listed in Table 17.

TABLE 17

Examples of skulls whose length, breadth and height are identical or closely similar but whose measured capacities are widely divergent

SKULL NO.	GROUP	L	B	H	CAPACITY PLASTIC METHOD	PREDICTED CAPACITY
1199	Male white	183	146	117	1333	1482
1255	Male white	183	146	117	1559	1482
Difference		0	0	0	226	0
2682	Male white	183	141	118	1300	1448
1641	Male white	184	140	119	1592	1455
Difference		1	1	1	292	7
2590	Male Negro	179	135	117	1578	1334
511	Male Negro	179	136	115	1299	1325
Difference		0	1	2	279	9
773	Female Negro	181	140	112	1479	1296
1122	Female Negro	182	139	113	1163	1304
Difference		1	1	1	316	8

When Stewart (6) selected 40 male Eskimo skulls which varied from one another not more than 4 mm. in each of the three external linear measurements he found a range of 230 cc. in their capacities. Similarly selected groups of Reserve male white and male Negro skulls show comparable ranges in cranial capacity. Male white skulls, numbering 24, whose lengths range from 178 to 181 mm., breadths

from 144 to 147 mm. and heights from 112 to 115 mm. range from 1232 to 1510 cc. in cranial capacity (by plastic method), a difference of 278 cc.

Male Negro skulls, numbering 25, whose lengths range from 186 to 189 mm., breadths from 136 to 139 mm. and heights from 113 to 116 mm. range from 1294 to 1492 cc. in cranial capacity (by plastic method), a difference of 198 cc.

Conversely, groups of skulls selected for their similarity in cranial capacity show wide ranges in external dimensions. Male white skulls, numbering 47, whose capacities (by plastic method) range from 1420 to 1429 cc. fall in the following intervals in the three linear dimensions and predicted capacity:

Length (gl)	169 — 193 mm.	24 mm.
Breadth	134 — 152 mm.	24 mm.
Height	107 — 124 mm.	17 mm.
Predicted capacity	1353 — 1536 cc.	183 cc.

Male Negro skulls, numbering 35, whose capacities (by plastic method) range from 1370 to 1379 cc. fall in the following intervals in the three linear dimensions and predicted capacity:

Length (gl)	179 — 194 mm.	15 mm.
Breadth	131 — 149 mm.	18 mm.
Height	107 — 124 mm.	17 mm.
Predicted capacity	1278 — 1493 cc.	215 cc.

It is clear, then, that as Lee and Pearson (5) and Stewart (6) among others recognized, a formula derived from a population's cranial length, breadth and height will not predict efficiently the cranial capacities of the same population. A possible practical use of such a formula is to obtain an estimate of the cranial capacity central tendency of one population by applying a prediction formula derived from another, but similar population, to obviate the labor involved in direct measurement of capacity.

An example of such an application follows. The Lee and Pearson formulae 8 for German male and German female have been applied to the Reserve male white and female white data. The Lee and Pearson capacities were measured by the seed method which, according to Todd's (8) early study of Reserve skulls, produces values about 80 cc. greater than those obtained by the water method. Data presented in the present report show that capacities obtained by the water method on wet, unmacerated skulls tend to exceed by about 15 cc., in the two

white samples, those obtained by the plastic method on the same skulls when dried and macerated.

Lee and Pearson German male		*Reserve male white*	
Length	180.58	Length	182.63 (S.O.)
Breadth	150.47	Breadth	144.58
Height	120.75	Height	115.83
C. index	83.30	C. index	79.67
Capacity	1503.72 (Seed)	Capacity	1452.27 (Plastic)
Formula	$C = 7.348\ L + 10.898\ B + 5.228\ H - 2094.31$	Formula	$C = 6.43\ L + 8.39\ B + 8.83\ H - 1953.22$

Applying the Lee and Pearson formula, which was derived from measurements of a brachycephalic population, to the Reserve means derived from measurements of a borderline brachycephalic population and using supraorbital length which more closely approximates the greatest length of Lee and Pearson than does glabellar length, the results are as follows:

Reserve skulls N	*Mean capacity Predicted by Lee's formula*	*Mean capacity Plastic method*	*Mean capacity Water method*	*Mean error*
1179	1428.85	1452.27	.....	— 23.42
668	1426.27	1447.12	.....	— 20.85
668	1426.27	.....	1462.24	— 35.97

The mean error, 23.42 cc., obtained when the Lee and Pearson formula for German males is applied to Reserve data, that is, the difference between the capacity so predicted and the mean capacity (by plastic method) of 1179 Reserve male white skulls, is well under the 40 to 50 cc. which Todd (7) considered a fair estimate of the personal error in direct measurement of capacity by the water method. Even the error, 35.97 cc., between the predicted capacity and the mean Reserve capacity by the water method with membranes intact is within this limit.

Lee and Pearson German female		*Reserve female white*	
Length	173.59	Length	174.01 (S.O.)
Breadth	144.11	Breadth	139.22
Height	114.17	Height	110.94
C. index	83.10	C. index	80.34
Capacity	1337.15 (Seed)	Capacity	1274.63 (Plastic)
Formula	$C = 7.065\ L + 10.126\ B + 4.848\ H - 1902.02$	Formula	$C = 6.65\ L + 8.58\ B + 8.16\ H - 1980.12$

Applying Lee and Pearson's formula derived from measurements of a brachycephalic population to the Reserve data derived from measurements of a brachycephalic population, using supraorbital length as before, the results are as follows:

Reserve skulls N	*Mean capacity Predicted by Lee's formula*	*Mean capacity Plastic method*	*Mean capacity Water method*	*Mean error*
182	1274.94	1274.63	.....	+ 0.31
112	1274.20	1276.39	.....	— 2.19
112	1274.20	.....	1292.15	—17.95

The mean error, 0.31 cc., obtained when the German female formula of Lee and Pearson is applied to Reserve data, or the difference between the capacity so predicted and the mean capacity by the plastic method of 182 Reserve female skulls, is remarkably small. The error, 17.95 cc., between the predicted capacity and the mean Reserve capacity by the water method with membranes intact, is slightly less than the difference 18.96 cc., obtained between the mean Reserve capacity by the water method with the membranes intact, and the capacity predicted by the Reserve female white formula, computed, of course, to predict capacity by the plastic technique.

However, if we accept Todd's finding that capacities obtained by the seed method tend to exceed capacities obtained by the water method by 80 cc. and if we consider that capacities by the water method have been shown here to exceed capacities by the plastic method by about 15 cc. in the female white sample, we are, then, left with the conclusion that had the Reserve female white capacities been measured by the seed method, the application of the Lee and Pearson German female formula to Reserve female white data would have resulted in an error of 95 cc. instead of 0.31 cc. The comparison of the cranial capacities of different population samples is hazardous and even meaningless unless the capacity measurements are known to have been made by the same technique. The application of a regression formula which has been derived from measurements of one population sample to the cranial length, breadth and height means of a second population sample for the purpose of obtaining a cranial capacity central tendency of the second population without making capacity measurements is a procedure whose result must be evaluated strictly in accordance with the known validity and accuracy of the capacity measurements of the first sample.

SUMMARY

An analysis of measurements made on 2241 skulls of the Reserve collection is reported. Of these skulls 1179 are male white, 661 are male Negro, 182 are female white and 219 are female Negro.

The technique of direct measurement of cranial capacity by use of a plastic material, devised by Professor Todd, is described.

Constants of central tendency and variability are reported for nine variables: supraorbital cranial length; glabellar cranial length; cranial breadth; auricular cranial height; cranial index; cranial capacity by the plastic technique; cranial capacity by the water technique with membranes intact; cranial capacity by the water technique with membranes removed; volume of the dura; body length. These constants are presented in Tables 2, male white; 3, male Negro; 4, female white; 5, female Negro.

The means of cranial capacity of wet, unmacerated skulls with membranes intact measured by the water method are found to be higher than means of cranial capacity of dried, macerated skulls measured by the plastic method. The differences are statistically significant but may be of little or no practical importance, particularly the differences of 15.12 cc. and 15.76 cc. found in the male and female white samples respectively.

The variability of Reserve whites tends to exceed that of Reserve Negroes in the dimensions studied.

The greatest difference between mean dura volume obtained indirectly and mean dura volume measured directly is 1.60 cc.

The means of cranial length and body length are greater in Negroes than in whites; the means of cranial breadth, height and capacity, dura volume and cranial index are greater in whites than in Negroes.

Sex differences between means of the dimensions studied are greater in whites than in Negroes, the only exception being volume of the dura.

The whites of both sexes tend toward brachycephaly whereas the Negroes of both sexes tend toward dolicocephaly. The cranial index is the variable showing the most significant racial difference and is the only variable showing an insignificant sex difference.

Correlation coefficients between measurements of cranial capacity by the water method before and after removal of the membranes are

all greater than 0.99. Correlation coefficients between capacity by the water method and capacity by the plastic method range from 0.94 to 0.96.

Intercorrelations among cranial linear measurements tend to be slightly higher in Negroes than in whites.

Multiple correlation coefficients between the criterion, cranial capacity (by the plastic method), and the three linear measurements range from 0.785 (female Negro) to 0.843 (male white). Cranial capacity of these four population samples cannot be predicted efficiently from the three cranial linear measurements of the same population samples.

A multiple regression formula to predict cranial capacity by the plastic method from the three external cranial measurements is presented for each of the four sex-color groups (Table 14).

Frequency distributions of prediction errors are shown to range, for all four sex-color groups, from — 244.40 cc. to + 227.87 cc. Skulls of the same length, breadth and height may differ from one another in capacity by more than 200 cc.

The application of a regression formula which has been derived from measurements of one population sample to the cranial length, breadth and height means of a second population sample for the purpose of obtaining a cranial capacity central tendency of the second population without making capacity measurements is a procedure whose result must be evaluated strictly in accordance with the known validity and accuracy of the capacity measurements of the first sample.

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THE POPULATION OF MEXICO IN 1793

BY S. F. COOK

INTRODUCTION

IN approximately the year 1790 the Viceroy of New Spain, Revilla-Gigedo, undertook to make a complete enumeration of the persons living within the confines of Mexico. Prior to his day various local authorities had made partial counts primarily for taxation purposes, but no general census had ever been attempted. Moving with the slowness characteristic of the later colonial administration, the Viceroy put his plan into effect. There emerged finally in 1793-1794 a fairly adequate census, the earliest we possess for the region concerned.

The actual counting was done by the local district and municipal authorities during the years 1791 to 1793. Each individual was listed (in long hand) by name, together with the sex, age, address, and occupation. The lists were then forwarded to the capital and there retained on file. Little attempt was ever made to organize the mass of original reports, beyond deriving obvious totals, and no one at the time or since has subjected the material to any statistical analysis.[1]

In the National Archive there are still preserved many of the original census sheets. During a visit to Mexico City in 1939 the writer, through the kindness of the Director of the Archive, was able to secure a transcript or abstract of the numerical data contained in these documents. This abstract forms the basis of the brief review here presented.

There are two documentary sources of the material. The first, here designated as *Series 1,* consists of the file, or *Ramo,* known as *Censos.* This file comprises some forty bound volumes of the original returns. Quite evidently all the returns never found their way into this series of volumes, for the total number of persons included repre-

[1] Baron Alexander von Humboldt, during his sojourn in Mexico, in 1808 was concerned with another census which he utilized as the basis for an analytical essay on demographic trends.

sents only a little over half a million, or approximately 10 per cent of the population of the country. This half million is from 67 cities and jurisdictions located exclusively in central Mexico. However, even though the returns are incomplete, the distribution is sufficiently even to warrant regarding them as a quite adequate sample of the territory.

Reinforcing and amplifying the original sheets is *Series 2*. This consists of numerous compilations, evidently made by the government from the census data, pertaining to certain large territorial subdivisions, in particular provinces. These compilations extend the number of inhabitants represented to approximately two and one-half millions, or fifty per cent of the total population, quite well distributed throughout the country. They are to be found in the file, or *Ramo*, known as *Historia*, volumes 72, 73, 522 and 523.

RACIAL COMPOSITION

The three component strains in the Mexican population have, since the conquest, been Caucasian, Mongolian and Negroid. The native population was pure Indian. The Spanish settlers contributed white blood, and many thousand slaves imported from Africa in the 16th century contributed the Negro blood. In 1793 the racial strains were sufficiently distinct to make possible some segregation in the census.

In Series 1 the basic subdivision was in four categories: *castizos, Españoles, mestizos,* and *mulatos*. The racial line was by no means absolute, for miscegenation by the end of the 18th century had proceeded to the point where very few absolutely pure bloods of any race were to be found. The categories of *castizos* and *Españoles*, therefore, applied to persons of predominantly white blood; *mestizos* referred to persons ranging from obviously white-Indian mixture to pure Indian; *mulatos* were persons of entire or partial Negro extraction, admixed with either white or Indian. These groups, therefore, represent ranges rather than pure, uniform segregations. With respect to the two semi-white categories, the term *castizo* refers to a person of relatively pure white descent who also occupied a superior social position; in other words, a member of the aristocracy. *Español* described a person of lower social rank who was definitely descended from the Spanish settlers.

In Series 2 there are but three categories: *Españoles, Indios,* and *mulatos*. Here the latter term has the same connotation as in Series 1: persons of obvious or entire Negro blood. *Españoles* includes the

castizos and *Españoles* of Series 1, whereas *Indios* is probably coterminous with *mestizos*. Some error is doubtless unavoidable in the assumption that these classes are exactly parallel in the two series, but no data exist as a basis for a more accurate segregation.

In Series 1 there are 48 towns and jurisdictions which report all classes of inhabitants. The total number was 521,785 of whom 86,558, or 16.4 per cent, were Negro or mulatto. (See Table 1).

TABLE 1

Racial composition as shown in 48 towns and jurisdictions from Series 1

RACIAL STRAIN	NUMBER	PER CENT
Negro	86,558	16.4
Mestizo	255,955	49.1
Español	149,695	28.7
Castizo	29,577	5.7
Total	521,785	99.9
Español plus Castizo	179,272	34.4

Since the areas are well scattered and representative, and the total is sufficiently large, the value of approximately 16 per cent may be taken as reasonably accurate for central Mexico, exclusive of Mexico City.

From Series 2 may be obtained additional information pertaining to the country at large. In Table 2 the population is segregated according to African and non-African descent. Fifteen major geographical regions are shown, more or less coinciding with modern state boundaries. The population figures are derived from three sources. The first consists of direct census figures, from Series 2, covering the provinces of Antigua California, Guanajuato, Mexico, Tlaxcala, Yucatan and Tabasco. The second consists of incomplete returns, from Series 1, and represents the totals of those towns and jurisdictions falling respectively in Aguascalientes, Queretaro, Hidalgo, Vera Cruz, Guerrero, Central and Eastern Michoacan, Puebla plus Morelos, and a region on the west coast which includes Jalisco, Nayarit, Colima and Western Michoacan. The third source is a calculated estimate for Oaxaca and Durango. For these provinces the total population is given in Series 2, but not the breakdown by races. However, in Oaxaca, we do have the data for the jurisdictions of Xicayan, Huamelula and Antequera. Applying the proportion of Negroes

TABLE 2

Racial composition according to major geographical regions
A—direct from census, Series 2. B—incomplete returns, direct from Series 1.
C—calculated estimates based on incomplete returns from Series 2.

REGION	SOURCE	NEGRO		MESTIZO AND INDIAN		ESPAÑOL AND CASTIZO	
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
1	A	183	5.01	3,234	88.56	235	6.43
2	B	2,409	10.97	10,849	49.46	8,682	39.57
3	B	3,051	59.40	153	2.98	1,934	37.62
4	A	72,276	21.38	175,182	50.15	102,306	29.36
5	B	5,358	6.79	58,294	73.90	15,232	19.31
6	B	3,481	18.11	9,539	49.69	6,195	32.21
7	B	7,073	14.97	15,262	32.20	24,897	52.75
8	A	52,629	5.66	742,186	79.90	134,965	14.45
9	A	697	1.35	42,878	83.10	8,021	15.55
10	B	15,984	14.29	52,564	46.85	43,349	38.80
11	B	5,745	12.88	31,026	69.60	7,826	17.55
12	B	14,285	69.80	2,613	12.77	3,568	17.43
13	A	45,201	12.42	264.955	72.70	53,866	14.78
14	C	20,600	5.04	299,000	73.80	85,100	21.00
15	C	70,100	59.02	28,200	23.77	20,400	17.20
Total		319,070	12.40	1,735,935	67.50	516,576	20.10
14 and 15 excluded		228,370	11.16	1,408,735	68.80	411,076	20.10
8 excluded		266,451	16.22	993,749	60.50	381,611	23.25

found in these three jurisdictions to the entire province the figures shown in Table 2 are obtained. Similarly in Durango the data for the jurisdictions of Durango and Mapimi are extrapolated.

In Table 2 the totals show African blood to be present to the extent of 12.40 per cent, or, if the provinces of Oaxaca and Durango be omitted, 11.16 per cent. These values are somewhat lower than that obtained from Series 1 alone. The difference, however, is largely accounted for by the very heavy weight contributed by the province and city of Mexico. If this province be omitted from the list the per cent of Negroes in the rest of the country becomes 16.22, or very nearly the value from Series 1.

These census returns give us 2,686,778 out of an approximate 5,200,000 for the whole country.[2] It is probable that the missing

[2] The grand total is not found in the National Archive documents seen by the author. However, it is stated to be 5,200,000 on page X of the preface to the *Quinto Censo de Población, Resumen General,* Mexico, 1934.

forty-eight per cent of the population corresponds to the sample for which we have data. Among the missing are the coastal belts of Vera Cruz and much of Guerrero which probably would show a high Negro population. But these would be offset by Sonora, Sinaloa, Chihuahua, Zacatecas and Nuevo Leon where the Negro influence was relatively slight. Assuming a value of 16 per cent for most of the country and taking the province of Mexico as 5.66 the final estimate would be approximately 14 per cent. In view of the many uncertainties a range of 12-15 per cent would probably be fairly consistent with actuality.

With respect to the inhabitants of white, mestizo and Indian blood, the two series differ more widely. The data from Series 1 (see Table 1) show 34.4 per cent to be in the predominantly white group and 49.1 per cent either of definitely mixed, or full Indian blood. When the two series are combined, as in Table 2, and the category "Indios" considered equivalent to "mestizos" the predominantly white component constitutes 20.1 per cent and the mixed or Indian component 67.5 per cent.[8]

The divergence is clearly marked in two individual cases. In Series 1 there are returns for four jurisdictions in the Province of Guanajuato, and one large jurisdiction in Tlaxcala. Series 2 gives the complete census for both provinces. The comparative percentages are as follows:

	Guanajuato Series 1	*Guanajuato Series 2*	*Tlaxcala Series 1*	*Tlaxcala Series 2*
Negroes	25.5	21.4	1.9	1.4
Mestizos or "Indios"	24.4	50.2	29.3	83.1
Españoles	50.1	29.4	68.8	15.5

The Negro population corresponds quite closely in both provinces but the mixed bloods and whites show wide deviations.

[8] The discrepancy in racial breakdown between the two series is puzzling. Without question the same basic enumeration is the source of both series. The most obvious difference is that noted in the introduction, i.e. Series 1 consists of the actual recordings taken in the field whereas Series 2 embodies a compilation of such recordings executed by the central colonial administration. It is quite probable that the racial grouping used by the field enumerations was reclassified by the government workers in Mexico City in conformity with their own ideas. No material change could be made in the number of Negroes or mulattoes but the various shades of white—Indian mixtures could easily be segregated in varying categories according to the anthropological, social and economic predilections of government officials.

A final exact conclusion cannot be reached. The best we can do is attempt a compromise by establishing limits. Accordingly it may be stated that in 1793 Negroes and mulattoes constituted from 10 to 15 per cent of the population, the predominantly white element from 20 to 35 per cent, the mestizo and Indian element 50 to 70 per cent.

SEX RATIO

The sex ratio may best be computed from Series 2. The data in terms of male-female ratio are given in Table 3 for 1,423,309 persons,

TABLE 3

Sex ratio

Based on Series 2. Data from Guanajuato, Tlaxcala, Mérida, Antequera, Durango, Antigua California and Mexico. 1,423,309 individuals.

AGE	0-7	7-16	16-25	25-40	40-50	50+	ALL AGES
Negro	1.022	0.987	0.917	0.967	1.041	1.008	0.985
Indio	1.117	1.121	0.914	0.963	1.098	1.067	1.035
Español	1.047	1.013	0.930	0.981	1.018	1.137	1.004
Total	1.093	1.094	0.917	0.967	1.076	1.074	1.026

a sample comprising 27.5 per cent of the entire population. The ratios for the three principal racial components are also shown.

The net ratio for the sample is 1.026. The racial components show some slight variation, a range from 0.985 to 1.035, but no really significant difference. The ratios according to age distribution are, however, of some interest. In each racial group, to a variable extent, and in the total population, there is a definite excess of males in the years from birth to sixteen. Between sixteen and forty the females are widely in excess followed by another reversal with an excess of males in the age groups over forty.

The high ratio in the younger age groups is in conformity with the excess of male births over female births found in most populations. The fall of the ratio in the post-adolescent period may also follow the frequently observed preponderance of male over female mortality. The reversal to a high ratio in the oldest age group may indicate a shift in the mortality trend favoring the males. This in turn could be ascribed to the strain of child bearing and severe domestic labor undergone by the women.

The data for Mexico in 1790 are shown in comparison with the Mexican census returns for 1900 and 1930 and with the native born whites in the United States as shown by the 1930 census. The same general trend is apparent in all four cases but the Mexican sex ratio seems to have been the more labile. Thus the extremes in the United States (see Table 4) for the three age groups given are 1.030 and

TABLE 4

Sex ratio in Mexico and the United States for the three principal age groups given in the 1793 census

	0-16 YEARS	16-40 YEARS	OVER 40 YEARS	TOTAL POP.
Mexico, 1793	1.090	0.944	1.075	1.026
Mexico, 1900	1.045	0.910	1.037	0.986
Mexico, 1930	1.047	0.900	0.935	0.962
U.S. white, 1930	1.030	0.991	1.021	1.011

Mexico, 1790—From National Archive records.
Mexico, 1900—*Quinto Censo*, 1930. *Resumen General*, p. 45.
Mexico, 1930—*Quinto Censo*, 1930. *Resumen General*, p. 47.
U.S., 1930—Fifteenth Census, 1930, Population, vol. II, p. 578.

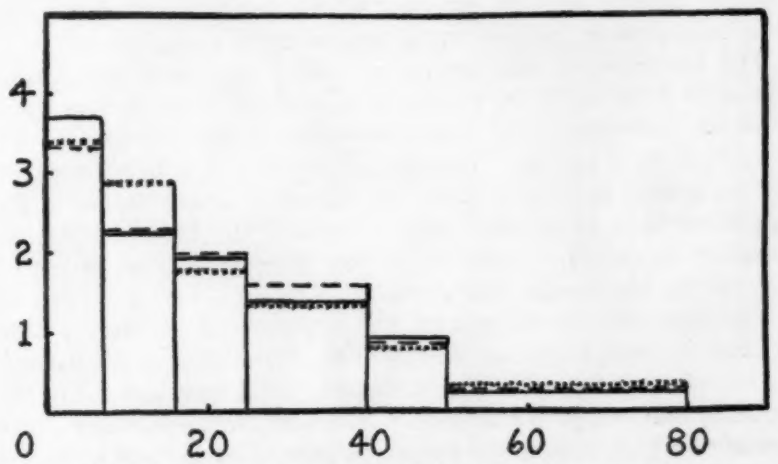

FIG. 1. AGE DISTRIBUTION AMONG THREE RACIAL TYPES IN THE 1793 CENSUS OF MEXICO

Horizontal axis—age period; vertical axis—per cent. Solid line—*Españoles;* broken line—*Indios;* crosses—Negroes.

0.991, a difference of 0.039. For Mexico in 1790, 1900 and 1930 the corresponding differences are 0.146, 0.135, and 0.147 respectively.

AGE DISTRIBUTION

Series 1 differentiates only between adults and children and is, therefore, useless for computing age distribution. Series 2 separates the population into six irregular age periods: 0-7, 8-16, 17-25, 26-40, 41-50, and over 50. In Fig. 1 is shown the graph derived from those data. It is apparent that the three primary racial groups do not differ to a material extent. Those variations which do appear are probably without special significance. For the purpose of comparing this population as a whole with other populations, the analogous data have been secured for Mexico in 1930 and native born white Americans in 1930 (see Fig. 2). The graph for Mexico in 1790 is shown to

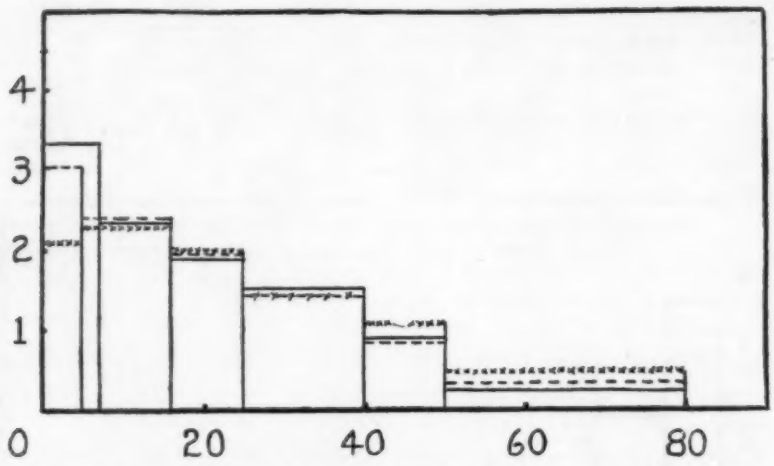

FIG. 2. AGE DISTRIBUTION FOR TOTAL POPULATION IN THREE CENSUS
Ordinates as in Fig. 1. Solid line—Mexico, 1793; broken line Mexico, 1930; crosses—U. S. native white, 1930.

be very close to that for Mexico in 1930, whereas that for the United States is significantly different. The latter population is well known to be shifting in favor of older age groups whereas that of Mexico is still youthful. Evidently there has been a preponderance in the younger ages of the Mexican population for at least 150 years.

MARITAL STATUS

The census returns in Series 2 shows marital status for a total of 1,639,799 persons, not all the available provinces having reported this particular type of information. For the sake of uniformity the data have been recast in percentage form and are presented in Table 5, together with comparable material from the Mexican 1930 census

TABLE 5

Marital state. Per cent distribution for all ages over 15 years

	MALE				FEMALE			
	Unmarried	Married	Widowed	Divorced	Unmarried	Married	Widowed	Divorced
Mexico, 1793	21.9	68.0	10.1	0.0	18.5	66.4	15.1	0.0
Mexico, 1930	32.2	62.5	4.8	0.5	30.8	54.4	14.3	0.5
U.S.A. Nat. white, 1930	36.8	58.0	4.0	1.2	29.5	59.8	9.4	1.3

Note to Tables 5, 6, and 7

The 1793 Census divides ages between 15 and 16 years. The 1930 Mexican Census makes the division at 15-16 for males and 13-14 for females. The American 1930 Census divides at 14-15 for both sexes. Some discrepancy is therefore introduced but is not of serious magnitude.

The 1790 Census shows no divorces. Consequently this, then, must be omitted for that census. In the Mexican 1930 Census no divorces under the approximate age of 15 are shown since divorce is illegal prior to that age. The American 1930 Census shows a few divorces under 15 years but the number is negligible.

and the United States Census of the same year with respect to native whites. Table 5 shows the marital status for the entire population over the approximate age of 14 years (see note to these tables). Tables 6 and 7 show the marital status with respect to three primary age groups. One or two noteworthy features emerge. From Table 5 it is clear that the tendency to marry was definitely greater at the earlier period than in modern times either in Mexico or the United States. It is, furthermore, probable that the mean age at marriage was younger in 1790 than it is now, although unfortunately an exact determination of this point cannot be made. In the Revilla-Gigedo census the first post-adolescent period is 16-25. In the Mexican 1930 census (*Resumen*) the periods are either 14 or 16 to 19, followed by 20 to 29. We may, however, get some clue by comparing both to the

TABLE 6

Marital state. Per cent distribution of marital condition for each age group

AGE	MALE				FEMALE			
	Unmarried	Married	Widowed	Divorced	Unmarried	Married	Widowed	Divorced
				1793 – Mexico				
0-16	96.6	3.3	0.1	0.0	95.1	4.7	0.2	0.0
16-40	28.9	67.1	4.0	0.0	22.1	69.9	8.0	0.0
40+	7.6	70.0	22.4	0.0	9.6	57.7	32.7	0.0
				1930 – Mexico				
0-15	100	0.0	0.0	0.0	100	0.0	0.0	0.0
15-40	44.6	53.7	1.4	0.3	38.7	56.6	4.2	0.5
40+	7.7	80.0	11.7	0.6	12.8	49.3	37.2	0.7
				1930 U.S.A. Native white				
0-15	100	0.0	0.0	0.0	100	0.0	0.0	0.0
15-40	53.3	45.3	0.6	0.8	41.2	56.0	1.6	1.2
40+	11.0	78.2	9.1	1.7	10.4	65.9	22.2	1.5

TABLE 7

Marital state. Per cent distribution of age for each marital condition

CONDITION	MALE			FEMALE		
	0-16	16-40	40+	0-16	16-40	40+
			1793 – Mexico			
Unmarried	78.7	18.8	2.5	79.6	17.3	3.1
Married	3.9	63.4	32.7	5.1	71.0	23.9
Widowed	2.1	26.0	71.9	1.7	36.8	61.5
			1930 – Mexico			
Unmarried	70.0	27.6	2.4	64.3	31.1	4.6
Married	0.0	57.4	43.6	0.0	69.1	30.9
Widowed	0.0	19.5	80.5	0.0	20.6	79.4
Divorced	0.0	49.3	50.7	0.0	60.0	40.0
			1930 – U.S.A. Native white			
Unmarried	57.2	37.9	4.9	62.0	32.9	5.1
Married	0.0	47.7	52.3	0.0	58.0	42.0
Widowed	0.0	20.8	79.2	0.0	10.2	89.8
Divorced	0.0	43.2	56.8	0.0	58.8	41.2

United States Census of 1930. Taking simply the per cent of unmarried persons, the values in 1930 for American native whites were, in age group 15-19, for males 98.2 per cent and for females 85.6 per cent. The corresponding values for Mexico in 1930 were for males 92.6 per cent and for females 76.6 per cent. It thus appears that in modern Mexico the trend is toward earlier marriages than in the United States.

Now, considering the age group 16-25 the values for unmarried persons in the Mexican 1790 census were for males 13.7 per cent and for females 11.9 per cent. The corresponding values in the United States were for males 66.6 per cent and for females 69.9 per cent. Such a great difference permits us to infer that marriage, as a rule, took place at a very much younger age in late colonial Mexico than either in modern Mexico or the United States.

OCCUPATIONAL DISTRIBUTION

Certain provinces, in Series 2, show a classification of those gainfully employed, according to certain rather crude subdivisions. The pertinent data have been presented in Table 8. Some explanation of this table is necessary.

The non-productive group includes clerical individuals of numerous categories, such as priests, monks, nuns and members of subsidiary organizations. All these I have included as *religiosos*. *Real Hacienda* refers strictly to the Royal Treasury and probably denotes tax gatherers, clerks, etc. Other government employees are not listed as such for which reason they probably are included in this category. *Militar* designates the total military establishment. *Estudiantes* refers to students in institutions beyond the primary level. *Hidalgos* denotes gentlemen of leisure and of noble blood, a social class which has long since disappeared.

The professional group includes the three dominant professions outside the church, lawyers, doctors, and public secretaries or scriveners. *Comerciantes* is the class of merchants and small shopkeepers who conducted independent enterprises. Group IV, denotes skilled labor, and includes the classes *fabricantes* and *artesanos,* that is, makers of all sorts of manufactured goods and master of the skilled trades. Group V, unskilled labor, embodies miners plus three other classes, the nomenclature of which is obscure. *Labradores* in a general way was used to designate farm and agricultural labor, whereas *jornaleros* had the broader connotation of journeyman laborers who might do farm

work but who might also perform other tasks. The term *gañanes* implies simply those who work for a living and doubtless includes within it many of the two preceding classes.

The term *tributarios* means literally tribute payers or taxpayers and is derived ultimately from the semi-free native class which was

TABLE 8

Distribution by occupation

OCCUPATION	ABSOLUTE NUMBER	ABSOLUTE NUMBER	PER CENT	PER CENT
Group I, non-productive				
Religiosos	4,226		0.778	
Real Hacienda	645		0.117	
Militar	3,490		0.642	
Hidalgos	960		0.177	
Estudiantes	826		0.152	
Total		10,147		1.866
Group II, professional				
Letrados y abogados	107		0.020	
Escribanos	43		0.008	
Medicos y cirujanos	54		0.010	
Barberos	638		0.116	
Total		842		0.154
Group III, commercial				
Comerciantes	3,710		0.681	
Total		3,710		0.681
Group IV, skilled labor				
Fabricantes	12,620		2.320	
Artesanos	37,183		6.836	
Total		49,803		9.156
Group V, unskilled labor				
Mineros	10,249		1.887	
Jornaleros	153,016		28.133	
Labradores	74,260		13.653	
Gañanes	30,256		5.563	
Total		267,781		49.236
Group VI, Taxpayers				
Tributarios	211,611		38.907	
Total		211,611		38.907
Total gainfully occupied		543,894		100.
Total population of provinces included	1,634,172			
Per cent gainfully occupied			33.24	

not enslaved completely by the *conquistadores* of the sixteenth century. It applies here primarily to the persons who either owned small holdings outright (in country or city), or who maintained some property on a lease or rental basis from the upper class *hacendados*. From the occupational rather than the social or financial standpoint, most of them fell with the group of unskilled labor, although their exact status cannot be determined with accuracy.

Looking at the picture as a whole it will be noted that in this sample of the population, only 33 per cent had any assignable occupation. The remainder were women, children and unemployed. This value may be compared with that of 31.21 per cent listed as "economically active" by the 1930 Mexican census. Apparently the basic economic structure of the country has altered little in the meantime.

Comparisons with respect to the distribution of employment within the "economically active" segment of the population are difficult. This is due to the entirely different type of classification used in recent censuses, wherein the subdivisions are based upon type of industry rather than type of labor. A few statements, however, are possible. Considering only the actively employed group as 100 per cent, the 1930 census shows for commerce, public administration, and the professions, respectively, 4.7, 3.1, and 0.7 per cent. The approximately corresponding values for 1790 were, respectively, 0.7, 0.8, and 0.2 per cent. One may assume, therefore, that the more intellectual pursuits have advanced relatively to a considerable degree in 140 years although unskilled or semiskilled labor is still by far the predominant occupation in Mexico.

URBAN-RURAL DISTRIBUTION

For two reasons the 1790 census is quite unsatisfactory with respect to this factor. In the first place, within the area covered the returns favor the larger localities. To be sure, the returns include the rural population of the most densely settled portion of central Mexico, but even here many of the more remote country districts are omitted in the existing records. Indeed it is quite possible that certain of the more difficult jurisdictions were never enumerated at all—for instance the inaccessible interior of Guerrero, Michoacan, Jalisco and Oaxaca. In the second place, the population sample preserved in both Series 1 and 2 does not include at all various provinces of predominantly rural character, for example San Luis Potosí, Zacatecas, Nuevo Leon, and the west coast. As a result any breakdown of distribution according

to size of town shows an excessive and unreasonable preponderance in favor of the urban population. In fact the raw data give a ratio of 3 to 2 for the population living in towns of more than 2,500 persons as opposed to that living in smaller communities. This is quite out of line with what we know on other grounds to have been the actual situation in colonial Mexico.

Despite these shortcomings of the census there do exist returns for more than 1,000 localities of various sizes. From this sample it is possible to derive a little information concerning racial composition and age distribution.

In Table 9A are shown the absolute and relative numbers of persons of Negro and non-Negro blood in localities of three general sizes. The

TABLE 9

Urban–rural comparisons

A

Negro distribution

SIZE OF TOWNS	NUMBER OF NON-NEGROES	NUMBER OF NEGROES	PER CENT OF NON-NEGROES	PER CENT OF NEGROES
1-5,000	250,680	64,120	79.7	20.3
5,000-25,000	141,496	21,395	84.9	15.1
25,000 +	166,102	10,024	94.3	5.7

B

Adult–child distribution

SIZE OF TOWNS	NUMBER OF ADULTS	NUMBER OF CHILDREN	PER CENT OF ADULTS	PER CENT OF CHILDREN
1-5,000	193,240	132,354	59.3	40.7
5,000-25,000	102,175	57,903	63.8	36.2
25,000 +	119,511	56,615	68.0	32.0

first consists of the rural group, approximately 1,250 towns and villages under 5,000 inhabitants. The second includes thirteen cities of moderate size: 5,000—25,000. The third consists of the two largest cities, Mexico City and Puebla. The trend appears fairly clear. The Negro element was essentially rural in character, since in the present sample 20.3 per cent of the small town and farm population was negroid as compared with 5.7 per cent in the big cities. This situation probably does

not reflect any marked aversion of the Negro component to urban centers. It is more simply explained by the fact that the upper class white population and generally the more intelligent and skilled mestizos tended to congregate in the only available centers of culture and industry, the largest cities, to the exclusion of the great mass of the population.

In Table 9B are shown corresponding data with reference to age composition. The analysis is of necessity very crude. The only utilizable categories in Series 1 are those of *adults* and *children*. This was taken as a rule to indicate, for children, males up to 16 years and females up to 14. In Series 2 for certain towns the line is drawn at 16 for both sexes. Thus we can determine only the relative number of persons in these two primary age groups. According to the data in Table 9B the larger towns show a distinctly smaller relative number of children, from which may perhaps be inferred that the reproductive rate was somewhat less there than in the rural districts at large. Such an inference would be more or less in accord with modern experience which indicates that urban society is less prolific than rural. The factors conducive to this difference were doubtless operative then as now.

POPULATION CHANGES DURING THE 18TH CENTURY

Although the earliest comprehensive census in Mexico was that of 1793 there exist a few scattered items which make possible an estimate of previous population. One of these is found in Vol. 72, pages 46-58, of the file *Historia,* contained in the National Archive. This is a census, taken in 1768 of 277 towns located in the province of Michoacan. It included the present states of Michoacan and Colima. In addition there is listed the population "*. . . a principio ó mediados de este siglo*". This statement is obviously very vague but since certain towns are listed, with early population figures, which were "destroyed" in the period 1735-1740, it may be assumed that the expression "beginning or toward the middle of this century" refers to a time prior to 1740. The year 1730 might be assumed as a fair indication of the general period.

According to these data the population of the 277 towns in 1768 was 72,515 while *ca.* 1730 it was 34,314. Now the earlier censuses may be tied in with that of 1793 by 15 towns which appear in all reports. In 1768 they had 5,908 inhabitants and in 1793 they had 5,653. The size of the sample (15 out of 277) is much smaller than

one would desire for a really adequate comparison. However, if we accept the data as they exist we may tentatively conclude that in this particular region there was no material population change between 1768 and 1793. The 15 towns are fairly well distributed both as to size and area and moreover it may be noted that Michoacan suffered extensively from various epidemics during this era, particularly that of smallpox in 1779. The figures in *Historia,* which must represent at least 20 per cent of the total population in the region show clearly a marked increase in the 40 years prior to 1768. Any continuation of that trend between 1768 and 1793 would certainly have been at least perceptible in the 15 critical towns. Actually the figures show a slight decrease. For this reason it is probable that the first half of the eighteenth century saw a considerable increase in numbers which ceased in the last three decades.

To extrapolate the Michoacan data to the whole of Mexico would be, of course, a procedure of doubtful validity. The primary objection is the very great question whether local changes in one province were truly representative of the country as a whole. I know of no direct evidence that they were. On the other hand I have no evidence to show that they were not. Michoacan is a large province, lying within the long settled central Mexican area. Social and economic conditions were relatively uniform in this part of the country. There were no major wars or disturbances. Epidemics, which were of frequent occurrence were, as a rule, universal rather than local in their effect. It may be argued more or less reasonably, therefore, that a period of marked population increase occurred during the first half of the eighteenth century to be followed by a stationary state during the ultimate decades. Using numbers, if the population in 1793 was 5,200,000, as shown by the Revilla-Gigedo national census, it may be assumed to have been roughly the same in 1768. Then the population in 1730-1740 would have been 2,450,000. This is in conformity with the broad trend of Mexican population as we know it.

It is generally held that the pre-conquest population was somewhere near 2,000,000, predominantly located on the central plateau, or at least in the belt between latitude 18° and 22° N. During the sixteenth century the native inhabitants were tremendously reduced in numbers whereas the white immigration was relatively small. No accurate figures are known but it may be inferred that by 1600 the total population was not more than a million. During the seventeenth century,

after the period of social and physical readjustment, the population must have begun to climb, and with minor regressions it has climbed ever since. It is certainly within the range of probability that by 1730 the total number of persons had reached well over two millions, and that the period 1730-1770 saw an acceleration of rebound from the low point of 150 years previously. Naturally, however, these speculations are but suggestive and must remain so until we acquire far more complete and accurate information. At such a time we may be able to set up a final and definitive record of the actual population changes in Mexico since the conquest.

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DERMATOGLYPHICS IN RELATION TO FUNCTIONAL HANDEDNESS

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SEVERAL investigations have been made in order to determine what relations, if any, exist between palm and finger dermatoglyphics and functional handedness. While almost all investigators agree in finding such an association, there has been considerable disagreement as to the details of its manifestations in the dermatoglyphics. There are numerous reasons for such discrepancies. The differences in the dermatoglyphics of right- and left-handers are of a subtle nature; they are apparent only through unlike frequencies of equivalent morphological traits, and for their demonstration comparatively large groups are required. Males and females show somewhat different trends, and certain investigators (Bettmann, 1932; Keith, 1917) have failed to take this into account. Different methods of formulation for palm patterns have been used by different investigators. Cummins (1931) counted only true patterns and marked vestiges in his analysis of 300 right-handers, whereas Leche (1933) included all vestiges in her comparison of 244 left-handers with the Cummins series. Newman (1934), in comparisons of 100 right-handers with 100 left-handers, counted the total number of patterns, even if two or more occurred on the same area. Obviously, this does not give the true ratio of patterned to patternless areas. No two investigators have used the same criteria for handedness. Due to different gene frequencies in different populations, we might expect discrepancies among Bettmann's (1932) group in Germany, Bonnevie's (1933) in Denmark, and the groups studied in various parts of America.

In spite of all of these sources of discrepancy all investigations have shown an increase of third interdigital patterns in the left hands of left-handers, as contrasted with the left hands of right-handers. With the exception of Keith, all investigators have found an increase in the occurrence of thenar/first interdigital patterns in left-handers,

although their findings in this area differ considerably in other respects.

One might expect more uniform findings in the third interdigital area for the following reasons. Patterns occur with high frequencies in this area, only the fourth interdigital exceeding it. Moreover, vestiges are comparatively infrequent in the third interdigital, while they are numerous in the fourth interdigital. Vestiges present the greatest difficulties of formulation of all configurations, and discrepancies in methods of classification are most likely in part responsible for lack of uniformity in data obtained from the fourth interdigital area. Patterns on other palmar areas and whorls on most finger tips occur with considerably less frequencies, and discrepancies among different investigators are probably due to insufficient numbers of subjects, as well as to variations in the methods of testing for handedness and differences in gene frequencies.

TABLE 1

Frequencies of patterns, both in percentages and actual numbers, on the palms of 300 right-handed and 418 left-handed males

AREA	TOTALS HAVING PATTERNS ON RIGHT HANDS		TOTALS HAVING PATTERNS ON LEFT HANDS		TOTALS HAVING PATTERNS ON BOTH HANDS		TOTALS HAVING PATTERNS ON RIGHT HANDS ONLY		TOTALS HAVING PATTERNS ON LEFT HANDS ONLY	
	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers
Hypothenar	42.3 127	43.5 183	42.0 126	44.0 184	29.0 87	30.6 128	13.3 40	13.1 55	13.0 39	13.4 56
Thenar/First Interdigital	8.0 24	6.7 28	16.3 49	16.6 69	7.6 23	6.0 25	0.3 1	0.7 3	8.6 26	10.6 44
Second Interdigital	8.6 26	8.9 37	4.6 14	4.8 20	3.0 9	2.4 10	5.6 17	6.5 27	1.6 5	2.1 9
Third Interdigital	64.3 193	61.3 254	34.3 103	36.8 153	29.6 89	31.4 130	34.6 104	29.9 124	4.6 14	5.5 23
Fourth Interdigital	52.0 156	59.4 245	69.3 208	73.1 303	42.3 127	49.5 205	9.6 29	9.6 40	27.0 81	23.7 98

TABLE 2

Frequencies of whorls, both in percentages and actual numbers, on the finger-tips of 284 right-handed and 430 left-handed males

The thumbs of only 427 left-handed individuals are included.

AREA	TOTALS HAVING WHORLS ON RIGHT HANDS		TOTALS HAVING WHORLS ON LEFT HANDS		TOTALS HAVING WHORLS ON BOTH HANDS		TOTALS HAVING WHORLS ON RIGHT HANDS ONLY		TOTALS HAVING WHORLS ON LEFT HANDS ONLY	
	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers
Thumb	39.7	35.8	29.2	26.2	22.5	21.0	17.1	14.7	6.6	5.1
	113	153	83	112	64	90	49	63	19	22
Index	36.9	30.7	33.0	29.0	22.6	20.2	14.0	10.5	10.1	9.3
	105	132	94	127	65	87	40	45	29	40
Middle	17.6	22.0	17.6	18.3	10.9	14.1	6.6	7.9	6.6	4.1
	50	95	50	79	31	61	19	34	19	18
Ring	56.0	49.7	39.0	37.8	35.2	32.7	21.0	16.9	3.8	5.1
	160	214	111	163	100	141	60	73	11	22
Little	22.5	21.6	16.5	15.8	12.3	12.5	10.3	9.0	4.2	3.2
	64	93	47	68	35	54	29	39	12	14

The investigation here reported was undertaken with the hope of obtaining enough data to give more exact information as to what sort of relationship exists between dermatoglyphics and handedness. The prints of 300 right-handed males, 300 right-handed females, 430 left-handed males, and 323 left-handed females were obtained. This group approximates in numbers of individuals the total of all previous investigations concerning which we have data. All of the subjects were whites of European stock, most of whom were school children in southwestern Ohio. As nearly as could be ascertained, none of those included was closely related to another subject. Miss Martha Craig, of Muskingum College, obtained the data on 100 of the left-handers, and the rest were taken by the senior author.

Uniform procedure was followed in the diagnosis of handedness, only unimanual operations were considered. The preferred hand in the

performances of the following operations was recorded: throwing, sewing, writing, hammering, sawing, shooting marbles, use of knife, bowling, use of scissors and spoon. Those performing all the above acts with right hand were classed as right-handed, and those who performed one or more of the above acts with the left hand were classed as left-handed. This method of classification is admittedly somewhat arbitrary, but is certainly more valid than reliance upon any single criterion. With the exception of writing, the majority of those classified as left-handers performed all operations with the left hand.

In our analysis of the prints, only finger and palm patterns were included. Fingers were classified as to the presence or absence of whorls. Palmar areas were classified as to the presence or absence of patterns, including vestiges, as distinguished from the strictly patternless

TABLE 3

Frequencies of patterns, both in percentages and actual numbers, on the palms of 300 right-handed and 322 left-handed females

AREA	TOTALS HAVING PATTERNS ON RIGHT HANDS		TOTALS HAVING PATTERNS ON LEFT HANDS		TOTALS HAVING PATTERNS ON BOTH HANDS		TOTALS HAVING PATTERNS ON RIGHT HANDS ONLY		TOTALS HAVING PATTERNS ON LEFT HANDS ONLY	
	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers
Hypothenar	52.0 156	50.6 165	51.0 153	51.2 166	39.3 118	40.0 129	12.6 38	11.1 36	11.6 35	11.1 37
Thenar/First Interdigital	6.6 20	12.1 39	9.6 29	13.6 44	5.0 15	9.3 30	1.6 5	2.1 9	4.6 14	4.3 14
Second Interdigital	5.6 17	3.4 12	3.3 10	4.6 15	2.0 6	1.5 5	3.6 11	2.1 7	1.3 4	3.1 10
Third Interdigital	57.3 172	63.6 205	35.0 105	39.1 126	29.6 89	32.6 104	27.6 83	31.3 101	5.3 16	6.8 22
Fourth Interdigital	58.0 174	57.4 185	74.6 224	68.0 221	51.0 153	47.5 153	7.0 21	9.9 32	23.6 71	21.1 68

TABLE 4

Frequencies of whorls, both in percentages and actual numbers, on the finger-tips of 288 right-handed and 323 left-handed females
Thumbs of only 317 left-handed individuals are included.

AREA	TOTALS HAVING WHORLS ON RIGHT HANDS		TOTALS HAVING WHORLS ON LEFT HANDS		TOTALS HAVING WHORLS ON BOTH HANDS		TOTALS HAVING WHORLS ON RIGHT HANDS ONLY		TOTALS HAVING WHORLS ON LEFT HANDS ONLY	
	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers	Right-handers	Left-handers
Thumb	35.4	34.7	30.5	30.6	22.5	23.0	12.8	11.8	7.9	7.5
	102	110	88	97	65	73	37	37	23	24
Index	33.3	32.8	32.6	31.8	24.6	23.2	8.6	9.5	7.9	8.6
	96	106	94	103	71	75	25	31	23	28
Middle	15.9	16.7	17.9	18.8	10.0	11.2	5.9	5.6	7.9	7.7
	46	54	52	61	29	36	17	18	23	28
Ring	47.5	44.8	37.1	37.7	31.5	30.8	15.8	13.9	5.5	6.8
	137	145	107	122	91	100	46	45	16	22
Little	13.8	15.0	13.8	11.4	7.9	7.7	5.9	7.1	5.9	3.7
	40	48	40	37	23	25	17	23	17	12

configurations, open fields and ulnar and carpal arches. In our classification we have counted for each area the number patterned on right hands, on left hands, those individuals having patterns on both hands, on right hands only, and on left hands only. Tables 1 to 4 show the actual numbers and percentages for each pattern area, grouped according to sex and handedness. The percentages are also represented in Fig. 1.

Note that the third interdigital area of left hands shows an increase in total patterns in the left hands of left-handers of both sexes (Tables 1 to 4), in accordance with the findings of all other investigators. There is an increase in the occurrence of thenar/first interdigital patterns in both hands of left-handed women. Table 5 shows the data of all investigators on frequencies of third interdigital patterns on left hands,

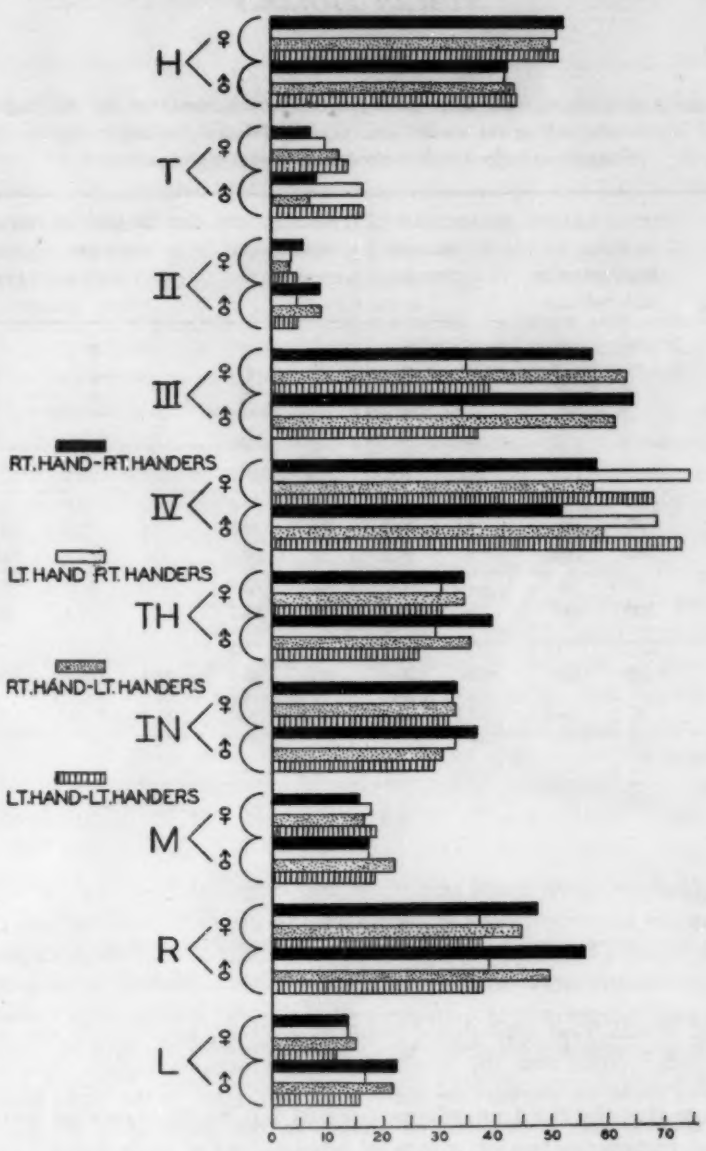

FIG. 1. DIAGRAMMATIC REPRESENTATION OF THE PERCENTAGES OF PALM PATTERNS AND FINGER WHORLS ON RIGHT AND LEFT HANDS OF RIGHT-HANDERS AND LEFT-HANDERS, GROUPED ACCORDING TO SEX.

Percentages correspond to those shown on Tables I-IV. H-hypothenar; T-thenar/first interdigital area; II-second interdigital area; III-third interdigital area; IV-fourth interdigital area; TH-thumb; IN-index finger; M-middle finger; R-ring finger; L-little finger.

TABLE 5

Data of five investigators concerning the frequencies of patterns on the third interdigital area of left-hands, and on the thenar/first interdigital areas of right and left hands combined, for both right-handers and left-handers

INVESTIGATOR	TOTAL NUMBER INDIVIDUALS		NUMBER PATTERNS ON THIRD INTERDIGITAL OF LEFT HANDS				NUMBER OF THENAR/FIRST INTERDIGITAL PATTERNS RIGHT AND LEFT HANDS COMBINED			
	Right-handers	Left-handers	Right-handers		Left-handers		Right-handers		Left-handers	
			No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
Cromwell	600	740	108	34.6	279	37.7	22	10.1	180	12.1
Keith	79	86	27	34.2	34	39.5	24	15.2	23	13.4
Newman	100	100	24	24.0	30	30.0	14	7.0	25	12.5
Bettmann	200	100	51	25.5	47	47.0	66	16.5	58	29.0
Cummins and Leche	300	244	82	27.3	87	35.7	33	5.5	49	10.1
Total	1279	1270	392	30.6 (Av.)	477	37.8 (Av.)	259	10.1 (Av.)	335	13.1 (Av.)
Difference between right- and left-handers				7.2 percent				3.0 percent		
Chi-square values with two degrees of freedom				$X^2 = 13.9$ Highly significant				$X^2 = 11.9$ Highly significant		

and of thenar/first interdigital patterns on both hands with the sexes combined. Note that the increase in each area is highly significant. Females show an increase of the third interdigital in the right hand of left-handers, and a decrease is shown in the occurrence of patterns in the fourth interdigital area of the left hands of left-handed women. Although statistically insignificant, these observations are in accord with those of most other workers. Our data show higher frequencies of hypothenar patterns than do those of other investigators due to our inclusion of all vestiges. This is especially marked in the females.

While other differences are shown in many of the comparisons of total patterns on right and left hands, all are statistically insignificant and do not appear to warrant further discussion.

Data by other investigators comparable to the last three columns of Tables 1-4 are not available. Examination of the third column of these tables reveals no significant differences between right- and left-handers in the percentages of individuals having patterns on both hands of any of the areas under consideration.

Columns showing the percentages having patterns only on right and only on left hands respectively, yield interesting results. Let us consider those pattern areas which are characterized by great bimanual variation in the occurrence of patterns, or in fingers, in the frequency of whorls. There are five such areas, the thenar/first, second, third and fourth interdigital areas, and the ring finger. Patterns occur with greatest frequencies on right hands in the second and third interdigitals and ring fingers, whereas left hands show the greatest pattern frequencies in the thenar/first and fourth interdigital areas. We shall henceforth designate the hand characterized by the greatest pattern frequency in a particular area as superior, and the hand possessing the lesser number of patterns for that area as inferior. Thus for thenar/first interdigital and fourth interdigital areas left hands are superior, whereas the right hand is superior in the ring finger, and the second and third interdigital areas. Note that there has been an increase in pattern frequencies in inferior hands of left-handers among females in each of the five areas under consideration. Likewise, there has been an increase in the same areas among males, with the exception of the fourth interdigital, where the value is exactly the same as for right-handers.

These data are summarized in Table 6. Note that the total differences between superior and inferior pattern areas are decreased in left-handers. Also note that in nine of the ten comparisons the inferior value of left-handers is greater than the inferior of right-handers. In the other comparisons no differences are shown. Table 7 shows comparisons of the number of inferior pattern areas with the total number of paired pattern areas in males and females, and also with the sexes combined. Note that females and the sexes combined, show significant increases in the total numbers of inferior pattern areas. The increase in males is not significant. Not only are the numbers of patterns greater in the inferior areas of left-handers,

but the total number of patterns are decreased in the superior areas of left-handers. For the individual pattern areas, however, there is an increase in the superior hands for the thenar/first interdigital and second interdigital areas of males, and for the third interdigital area of females, the other seven areas showing a decrease of patterns

TABLE 6

Comparative frequencies of superior and inferior patterns in right- and left-handers

REGION	RIGHT-HANDERS				LEFT-HANDERS			
	Superior		Inferior		Superior		Inferior	
	No.	*Percent*	*No.*	*Percent*	*No.*	*Percent*	*No.*	*Percent*
				Male				
Thenar	26	8.6	1	0.3	44	10.6	3	0.7
Second interdigital	17	5.6	5	1.6	27	6.5	9	2.1
Third interdigital	104	34.6	14	4.6	124	29.9	23	5.5
Fourth interdigital	81	27.0	29	9.66	98	23.7	40	9.66
Ring finger	60	21.0	11	3.8	73	16.9	22	5.1
Total	288	...	60	...	366	...	97	...
				Female				
Thenar	14	4.6	5	1.6	14	4.3	9	2.7
Second interdigital	11	3.6	4	1.3	7	2.1	10	3.1
Third interdigital	83	27.6	16	5.3	101	31.3	22	6.8
Fourth interdigital	71	23.6	21	7.0	68	21.1	32	9.9
Ring finger	46	15.8	16	5.5	45	13.9	22	6.8
Total	225	...	62	...	235	...	95	...
Total males and females	513	...	122	...	601	...	192	...

TABLE 7

Comparative frequencies of inferior pattern areas among total paired pattern areas included under our classification of superior and inferior

There are five such areas on each hand. The Chi-square values shown above were obtained from analysis in 2 x 2 tables. Any X^2 values of 3.841 or above are considered significant.

TYPE OF INDIVIDUALS	NO. PAIRED PATTERN AREAS WITHOUT INFERIOR PATTERN	NO. INFERIOR PATTERNS	TOTAL NO. PAIRED PATTERN AREAS	X^2
Right-handed males	1424	60	1484	0.66
Left-handed males	2005	97	2102	
Right-handed females	1426	62	1488	4.55
Left-handed females	1516	95	1611	
Right-handed male + female	2850	122	2972	4.1
Left-handed male + female	3521	192	3713	

in superior hands. The net effect is a slight lowering of bimanual asymmetry in populations of left-handers, as contrasted with populations of right-handers.

SUMMARY

Comparisons of the palm and finger patterns of 600 right-handers with those of 740 left-handers, grouped according to sex, reveal a slight but significant increase in the occurrence of inferior patterns in left-handed females. While statistically insignificant, similar trends are shown in males.

The combined data from five investigators, including 1279 right-handers and 1270 left-handers show highly significant increases of patterns in the third interdigital area of the left hands of left-handers and also of thenar/first interdigital patterns in both hands of left-handers.

The differences between the pattern frequencies of right-handers and left-handers are slight as compared with the bimanual differences occurring within individuals. Nevertheless, they are consistent and in

view of the fact that dermatoglyphics are established several months before birth, indicate beyond any reasonable doubt the existence of an anatomical basis for functional handedness.

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CORRELATIONAL ANALYSES OF THE INFLUENCE OF BASAL CHRONOLOGICAL AGE ON IQ RELATIONSHIPS TO SPECIFIED ANTHROPOMETRIC MEASUREMENTS

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APPARENTLY it is a fairly well accepted fact that a child's IQ bears little if any significant relationship to his physical status. Although it probably is true, as Hollingworth (4) has maintained, that a large group of children with high IQ's will be higher, *on the average,* on certain physical measurements than the average of normal IQ children on these same measurements, and though these latter likely will be higher, *on the average,* than the average of children with low IQ's, the fact remains that this relationship is seen almost exclusively at or around the points of central tendency. Where correlational techniques have been applied to this relationship, and where mutually influencing variables, such as maturity, have been held constant, either empirically or mathematically, the resulting coefficients, as noted by such authors as Baldwin (1), and Paterson (5), seldom have been in excess of .20 to .25. All of this points to the likely invalidity of individual diagnosis with respect to one variable from a knowledge of status in the other variable. It points to the fact that despite many propagandizing educational shibboleths, such as "a strong mind in a healthy body," and a certain amount of wishful thinking on the part of some, there has remained little evidence of significance to indicate that physical status had a relationship of any very positive significance to the brightness of the child.

At the same time that this problem was being investigated, another was being debated by the psychometricians themselves. This related

to the matter of the most valid basal age to use in the computation of intelligence quotients. Conventionally, Terman (6) has been followed for adults, and a basal age of 16 years has been employed in the formula $IQ = \frac{MA}{CA}$. Others, such as Wells (7), Hollingworth (3), and the senior author (2), have concluded in favor of a basal age of 14 years. Then there have been those who have suggested 15 as the most desirable basal age. In any event, however, the apparent hiatus with respect to computing IQ's seemed to the present authors to justify another investigation of the original problem pertaining to IQ-physique relationships. Accordingly, the present study approached the matter from the standpoint of the possible influence of the different basal age concepts upon relationships obtained and conclusions reached.

In order to get at this problem 78 boys and 121 girls, who graduated in the years 1933, 1934, 1935, 1937, 1939, and 1940* from the Peabody Demonstration School, were selected for study. These were all the graduates of these years for whom complete psychological, educational, and physical records were available. Chronologically, they ranged from 14 to 20 years in age. All records used were those recorded as a result of the routine examining conducted within the school by the psychological, physical education, and health divisions. The physical measurements chosen for study were: standing height, sitting height, weight, breathing capacity, head circumference, abdominal

TABLE 1

Statistical analyses of intelligence quotient distributions prepared on the basis of basal ages of 14, 15, and 16 years, each sex separately

	IQ (14)		IQ (15)		IQ (16)	
	Boys	Girls	Boys	Girls	Boys	Girls
Upper quartile	140.13	133.25	130.13	124.25	124.69	120.55
Median	124.00	122.50	115.56	114.88	110.77	109.58
Lower quartile	115.21	112.36	107.75	106.16	102.50	100.89
Quartile deviation	12.46	10.45	11.19	9.05	11.10	9.83
Highest score	143.00	143.00	143.00	135.00	143.00	135.00
Lowest score	89.00	96.00	83.00	89.00	78.00	84.00

* These years were used because the Kuhlmann-Anderson Test, a psychological or intelligence examination, was administered each year to the high school seniors.

circumference, chest width, and chest depth. Though these measurements were selected quite arbitrarily, from the total list of measurements available for study, it was the belief of the authors that they constituted a fair and adequate sampling of the anthropometric data.

In order to note the general brightness characteristics of the groups under investigation, and, further, in order to see the effect on the average of using three different basal ages in the computations of intelligence quotients, Table 1 is presented. Naturally, an appreciable effect resulting from changes in basal ages is seen on the medians, and

TABLE 2

Coefficients of correlation between the physical measurements and IQ's computed from designated basal ages

PHYSICAL MEASUREMENT	BASAL C.A.	COEFS. OF COR.	
		Boys	Girls
Height: standing	14	.17	—.05
	15	.17	—.02
	16	.15	—.05
Height: sitting	14	.24	—.11
	15	.24	—.13
	16	.22	—.11
Weight	14	—.05	—.02
	15	.11	—.03
	16	—.12	.02
Breathing capacity	14	—.10	—.08
	15	—.02	—.09
	16	—.06	—.07
Head circumference	14	.26	.04
	15	.27	.03
	16	.23	.18
Abdominal circumference	14	—.17	—.06
	15	—.16	—.05
	16	—.17	.01
Chest width	14	—.01	.05
	15	—.04	—.02
	16	—.08	—.01
Chest depth	14	.04	.03
	15	.02	—.03
	16	—.02	.01

relatively less effect is observable on the extremes of the ranges. By any basal age standard, though, it is quite apparent that the groups, on the average, are composed of bright children, probably somewhat brighter than the average high school graduate who takes this test.

In Table 2 one will find a summary of the coefficients of correlation obtained in the present study. A review of this table will show, almost beyond question, that the basal age used in computing the intelligence quotients in this study in no way disturbs the earlier mentioned conclusion, namely that there is no diagnostically significant relationship between intelligence brightness, as measured by a frequently used psychological test, and certain customary anthropometric measurements. Among the measurements for boys, the greatest obtained difference in coefficients is found in the weight-IQ measurements, where, using a basal age of 15, a coefficient of + .11 was obtained, as compared with a coefficient of — .12 when a 16-year basal age was employed. If we compute the statistical significance of this difference of .23 by means of the formula

$$P.E._{\text{diff. } r} = (P.E._{r_{12}}^2 + P.E._{r_{13}}^2)^{1/2},$$

we find a P.E. of .095. This would indicate that the critical ratio of the difference is only 2.4, as opposed to the more conventionally accepted standard of 4.0. Thus, we probably are not safe in assuming that this difference does not result from chance or fortuitous variations in the data. Or, again, it is altogether likely that the difference does not point to any basic differentiation in the data.

About the same condition exists with respect to the girls. The greatest difference seen is within the head circumference-IQ measurements where the 15-year basal age resulted in a coefficient of .03, and the 16-year basal age resulted in a coefficient of .18. The difference of .15 has a probable error of .085, resulting in a critical ratio of only 1.77. So, even more than with the greatest difference noted with boys, this difference would appear entirely too small to justify a positive generalization.

When these data are reviewed in their entirety, from an interpretive point of view, it is quite evident that they point strongly to the independence of the variables under investigation, irrespective of the basal age criterion used in IQ computations. It is striking to note that the highest obtained coefficient, that for the head circumference-IQ relation-

ship, for boys, when a 15-year basal age is used, is only .27, which results in a coefficient of alienation of about .963 for this same relationship. From the standpoint of individual diagnosis this latter coefficient, of course, indicates that one would have little better than a pure chance opportunity to predict from one variable to the other. Accordingly, in so far as this study is concerned, we find no evidence of the basal age concept employed in computations of intelligence quotients, or measures of brightness, being a factor of significance in IQ-physique relationships.

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NOTES

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2. *Human Evolution*

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